DESIGN edition

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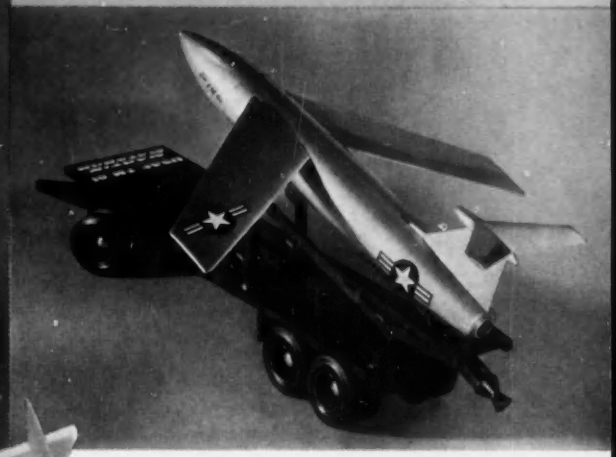
Product Engineering

McGRAW-HILL MAGAZINE OF DESIGN
RESEARCH AND DEVELOPMENT



Design for Man or Robot?
. . . page 5

You get automatic foolproof lubrication with LUBRIVAL circulating oil system

FARVAL—
Studies in Centralized Lubrication
No. 207

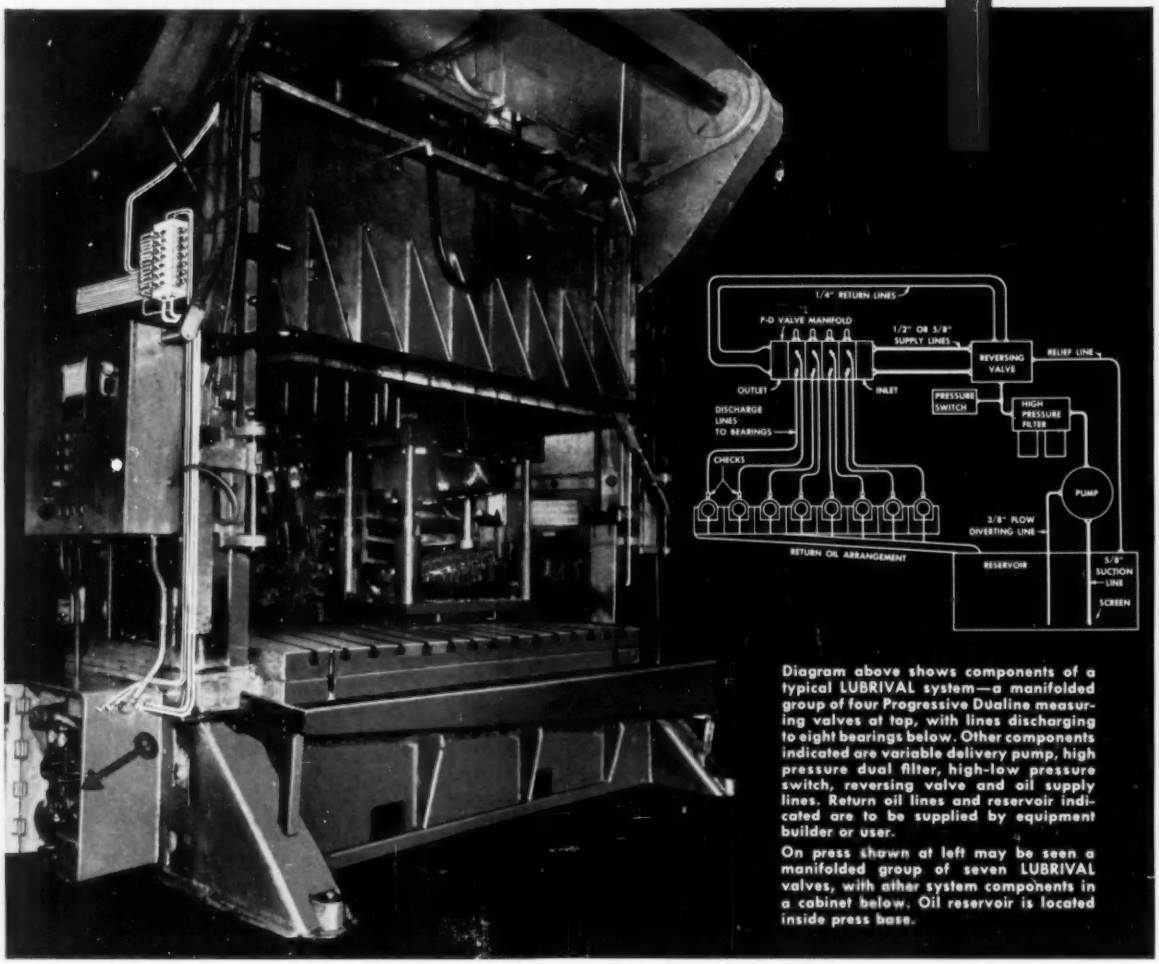


Diagram above shows components of a typical LUBRIVAL system—a manifolded group of four Progressive Dualine measuring valves at top, with lines discharging to eight bearings below. Other components indicated are variable delivery pump, high pressure dual filter, high-low pressure switch, reversing valve and oil supply lines. Return oil lines and reservoir indicated are to be supplied by equipment builder or user.

On press shown at left may be seen a manifolded group of seven LUBRIVAL valves, with other system components in a cabinet below. Oil reservoir is located inside press base.

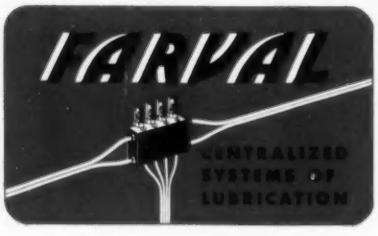
● The bearings of this 150-ton metal stamping press and others of its type are now protected by LUBRIVAL. This new Farval system for circulating oil is being installed on many varied kinds of machine tools, presses, automated machines, and other equipment calling for circulating oil lubrication.

Employing the famous Dualine principle, LUBRIVAL delivers oil to manifolded measuring valves which feed it under pressure to the bearings. Lubricant is force-fed by positive piston displacement. Flow can be regulated over a range of 10 ounces to one gallon per minute. Valves have individual sight indicators and a pressure-sensing mechanism warns of blocked or broken lines in any part of the system.

The Farval representative near you will give you all details. Or write for Bulletin 70. The Farval Corporation, 3279 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

KEYS TO ADEQUATE LUBRICATION—
Wherever you see the familiar Dualine valve manifolds, dual lubricant lines and central pumping station, you know a machine is being properly lubricated. Farval manually operated and automatic systems protect millions of bearings.



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Armco continuous hot-dip process produces a tightly-adherent zinc coating that flows with the steel base, creates cost-cutting possibilities.

More than 21 years' successful use of Armco ZINCGRIP Steel for products ranging from buildings to chicken feeders proves that its special zinc coating won't flake or peel despite severe working.

These electrical meter boxes are typical examples. Their fabrication involves deep drawing, severe forming and extrusion. But the tightly adherent coating on ZINCGRIP provides unbroken protection against corrosion, assures longer service life for your products.

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In addition to providing a workable zinc coating, Armco ZINCGRIP offers you opportunities to cut costs. The ability of the coating to withstand any kind of fabrication often means elimination of entire production operations. For example, many parts are made of ZINCGRIP at less cost than the same parts made of painted or plated cold-rolled steel. And because Armco ZINCGRIP is produced in both sheets and coils you can fabricate it with production line equipment.

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Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

October 28, 1957 Vol. 28, No. 17

STAFF REPORT

Transistors vs Tubes— 52 . . .
Along with specific performance characteristics, general advantages—and limitations—are given for transistors, fast-growing rivals to the electronic tube.

Hot-dipped Aluminum Coatings— 57 . . . Herbert Kee, Assistant Editor
Aluminizing is recommended where corrosion contaminates products, poisons catalysts, causes troublesome precipitates. Here is an increasingly popular method.

Higher Pressures for Mobile Hydraulics— 60 . . . W. R. Master, Dynex, Inc.
The 3000-to-6000-psi circuits offer a lower-cost answer in many applications.

Design Features in New Products— 62 . . .
Castings, weldments form press frame; shaft end-play adjustment; plastic parts in food blender; 500-ton ladle crane; development of printer slotter; turret-mounted drive for industrial tractor.

Ni Alloys Control Thermal Expansion— 68 . . . E. M. Wise, International Nickel Co.
They are an answer when swings in temperature make it hard to control critical dimensions in assemblies. Article tells which alloy to use, and when.

Water Lubricated Ball Bearings— 72 . . . P. R. Eklund, Westinghouse Electric Corp.
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How to Design Involute Splines— 75 . . . Darle W. Dudley, General Electric Co.
Involute form is now standard for both fixed and flexible couplings—single or double systems. Here are charts and tables for selecting size, face width, tooth form, number of teeth, pressure angle, and tooth height.

Electroplated Alloys— 81 . . . R. T. Gore, and R. M. MacIntosh
They offer coating properties that single-metal deposits cannot match—a guide to useful applications for all types.

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Aligning Sheets and Plates— 94 . . . F. Strasser
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Which Rivet to Use— 97 . . . Henry Peterson, Judson L. Thompson Mfg. Co.
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Produces automotive parts automatically ...with TIMKEN® bearings, the precision is automatic, too

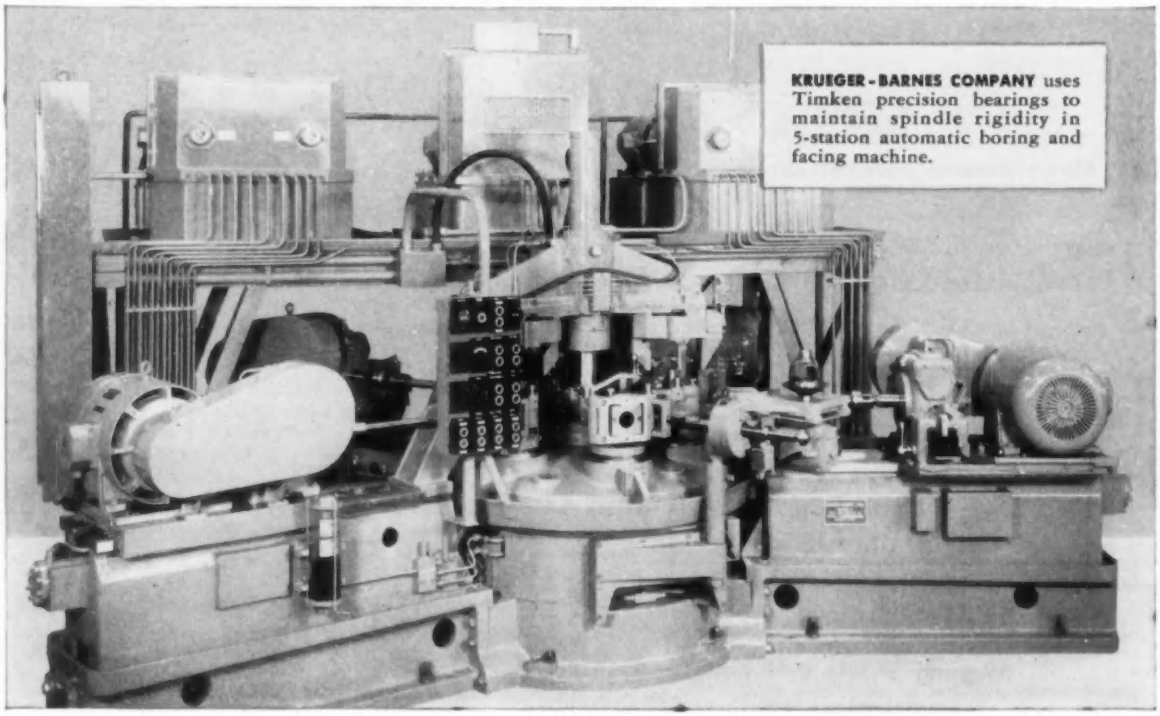
KRUEGER-BARNES engineers designed this 5-station milling and boring machine to produce automotive differential cases semi-automatically. To be sure its precision was automatic, too, they mounted the 5 spindles on 10 Timken® tapered roller bearings. Timken bearings take the work loads, keep the spindles rigid through hour after hour, shift after shift of high-speed operation. And they do it with a minimum of attention and maintenance.

Timken bearings maintain spindle rigidity because their tapered design lets them take both radial and thrust loads in any combination. And full line contact of rollers and races in Timken bearings gives them extra load-carrying capacity.

Timken bearings are designed by geometrical law to have true rolling motion and precision manufactured to live up to their design. Manufactured with an incredibly smooth surface finish, Timken bearings virtually eliminate friction, help keep machines on the go with less maintenance.

Since Timken bearings are engineered for the job, precision manufactured and made of special analysis Timken fine alloy steels, they normally last the life of the machine. In machine tools as in all machinery, wherever wheels and shafts turn, Timken bearings are your No. 1 value. When you build or buy machines, specify Timken bearings. Look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



KRUEGER-BARNES COMPANY uses Timken precision bearings to maintain spindle rigidity in 5-station automatic boring and facing machine.

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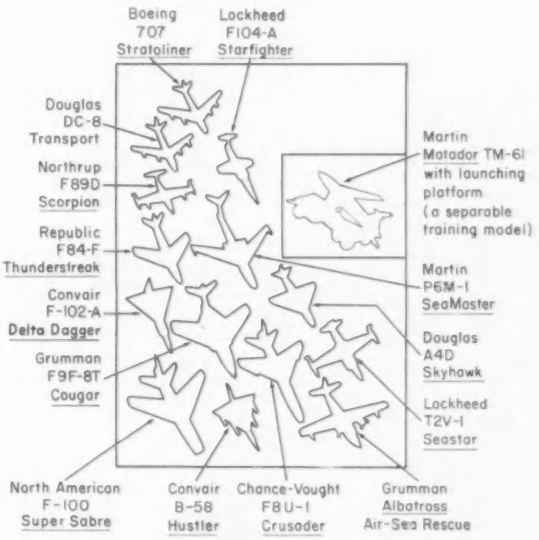

Models, Models, Models

Shortly after our invasion of Africa in World War II, one Allied airfield was constantly on red alert. Every time a new squadron of planes was flown in, the Luftwaffe came over and plastered them. A thing like this eventually becomes exasperating, even to a base commander. But this commander, when irritated, also became ingenious. He had his crews build a series of wooden mockups which he set out realistically on the field. The Luftwaffe arrived on schedule. But this time they dropped wooden bombs.

That's one application of models that didn't pan out, but many of them do, and spectacularly—witness the case studies in our story on the subject (Sept. 16 '57, p.99). We continually encounter them for all sorts of purposes, but some of the most decorative are those of aircraft. Some are built up from kits (like the Northrup F89D on our cover) but many are plastic assemblies of surprising detail. So our chief editor, who has friends in most of the aircraft companies, collected the group for our current cover. They're all latest jet models (except the Grumman *Albatross*) and all military except the two commercial transports at top, which are not yet in service.

A cover such as this takes much studio work. The trick in this case was to paint all the bases holding models in the same color as the background, to make them inconspicuous. Note, too, that all planes are identified for enthusiasts in the sketch above. This cover was planned—and in production—long before *Sputnik* began

(Continued on page 7)

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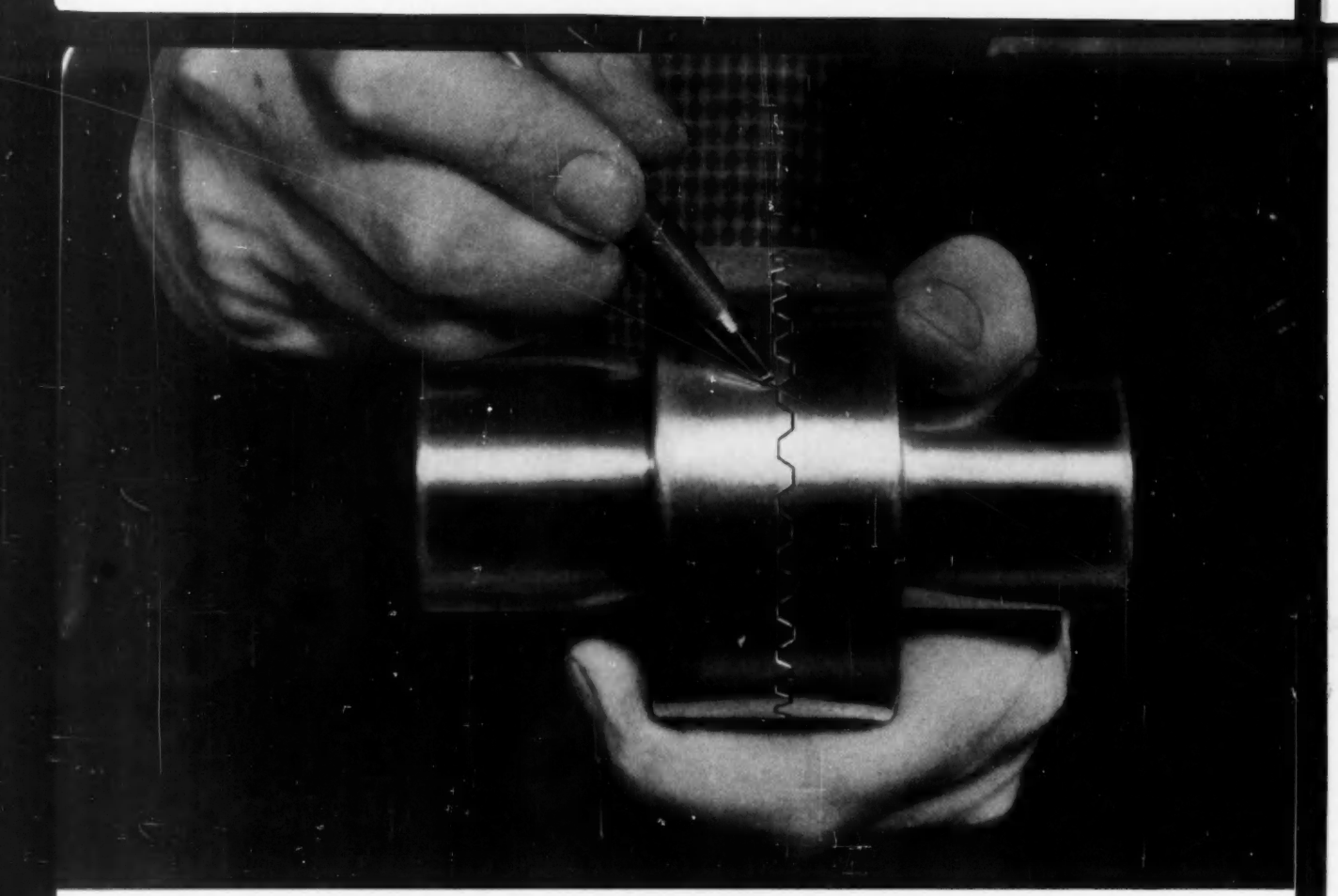


This photograph shows tooth contact of a Curvic Coupling used in an aircraft drive shaft. The coupling simplifies the manufacture and assembly of this shaft and permits "in the field" maintenance.

CURVIC® COUPLINGS—*what they are and how they can help improve your product*

Curvic Couplings are precise face splines that drive, center and align parts with a high degree of accuracy.

They can improve your product by giving improved design, simplify maintenance through the use of interchangeable parts and lower production costs by eliminating the need for large complex parts.

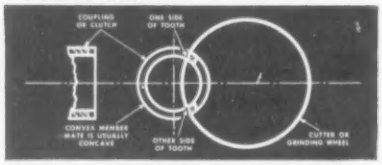
Because Curvic Coupling teeth curve lengthwise—either concave or convex—contact between the joining teeth is controlled. The load carried is equally distributed on all teeth as tooth-to-tooth spacing is held to extremely close limits. Therefore, Curvic Couplings can be made smaller, thinner and lighter than many other types of toothed connections.

Three principal types

1. *The permanent Curvic Coupling* is used for driving *and* aligning. It is for such uses as building up accurately balanced, precision rotors for jet aircraft engines. Curvic Couplings can hold mating parts within 0.0005″ total runout.
2. *The semi-universal Curvic Coupling* allows misalignment of shafts (2° maximum) together with axial freedom. Localized tooth bearing prevents load concentration on ends of teeth.
3. *Shift and overload Curvic Clutches* maintain proper tooth contact while the clutch engages and disengages. Shift clutches are used in washing machine wringer drives, motor trucks, outboard motors, aircraft —wherever a positive toothed clutch is needed.

Overload clutches are used where the amount of torque to be transmitted must be regulated, as in power screwdrivers.

The Gleason Engineering Department will be glad to consult with you regarding Curvic Couplings for your product. Write for our booklet.



The drawing above shows the method of producing both sides of Curvic Coupling teeth with the same surface of the cutter or grinding wheel, so that both sides have the same curvature. Curving the teeth lengthwise in this manner assures control of contact between joining teeth.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

Interesting to Note . . . . *(continued)*

to circle the earth, but the question the cover poses is singularly appropriate in the light of that achievement.

Notice that the two Navy trainers (T2V and F9F-8T) are trimmed in brilliant orange. This is probably like the signs on some cars saying—"Beware . . . student." Although each model is to scale, the same scale doesn't hold for the group. The Air Force's *Matador* missile, first to go into production, is a scale model actually assembled the way the missile itself is assembled. It's complete, with an enclosed scale engine, and is used for training. Will the missile obsolete the airplane? How does the airplane-missile controversy affect design? See page 85.

Nickel Plate Road

When the expansion boom dominated America during the late 19th century, railroads were considered the way to an easy fortune. Miles of steel already snaked between distant Western cities, bringing livestock to market centers. It was, therefore, a relatively easy job to convince a syndicate that a rail link between New York, Chicago and St. Louis would be a profitable venture. At a meeting in New York in 1881, $13.5 million was raised in less than 15 minutes. Thus a railroad was born "with a silver spoon in its mouth."

When announcement of the project appeared in the Norwalk (Ohio) *Chronicle* the proposed line was dubbed "the great New York and St. Louis double track, nickel plated railroad." Later, while attempting to induce the company to build the line through Norwalk instead of Bellevue, Ohio, the *Chronicle* again referred to the road as "nickel plated"—a term regarded as indicative of the project's glittering prospects and substantial financial backing. The name stuck and it is today the Nickel Plate Road.

It's not strange that nickel was a term of value; as an element it was known over 2000 years ago, and today there are more than 3000 nickel alloys. Its uses vary from a name tag, to trace the movements of Alaska fur seals, to a jet engine, which may use over a ton of the metal. The article on page 68 discusses the thermal expansion properties of nickel alloys.

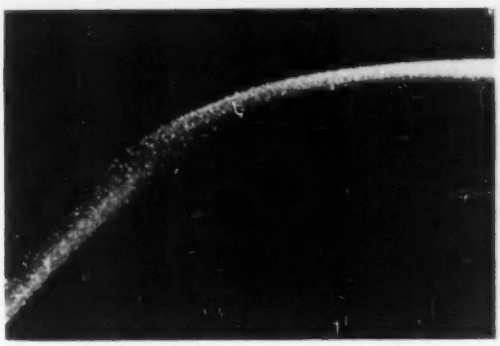
Printing Pioneer

Printing a hundred years ago was a painstaking operation—presses were the flat-bed type. A large cylinder, with a sheet of paper gripped tightly to it, rolled across a flat bed of type and if it didn't break down, was capable of turning out about 4,000 impressions per hour. The printing industry realized the need for faster presses. Simplest solution was a press with revolving cylinders faced with type—like a clothes wringer. It was a good idea, but unfortunately, no one could devise a method of holding the type to the cylinder face. For years, experiments were made with wedge-shaped type, but to no avail. At high speeds, the type would fly about the room like shrapnel.

It was the printer, Richard Hoe, who came up with the simple solution. Instead of making the type wedge-shaped, he made the column rules wedge-shaped. This effectively locked the standard parallel-shaped type to the cylinder face by friction.

In 1847, Hoe's first press was used by Philadelphia's *Public Ledger*. It was a large central printing cylinder with four impression cylinders, and turned out 10,000 impressions per hour. With this wedge idea, the printing industry boomed.

A recent addition to printing know-how is a press for corrugated board described on page 62. The press not only prints in four colors, but slots the board as well. Last year, nearly 98 billion sq ft of corrugated containers went through the mails.



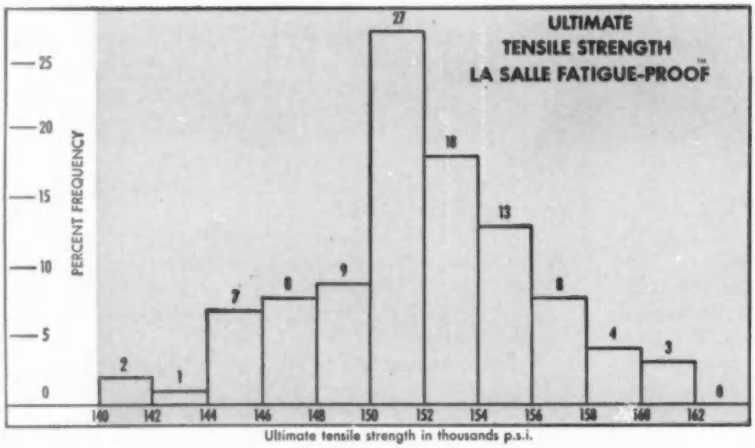
Tin whisker 0.001 in. dia, at 20 power magnification, grown at Boeing Airplane Co.

Tin Whisker Research

During the war, radio communications often went on the blink at crucial moments—aircraft landings, operational reports, or vital weather messages. The term "Gremlin" was conceived to explain these mysterious electrical failures. Recently, however, some of the deeds attributed to the pesky gremlins have been explained by technicians at the Bell Telephone Labs as "metal whiskers." These tiny metal spines are almost as mysterious as the gremlins—except that they can be studied in a lab.

It has been found they grow on tin, zinc and cadmium, and will actually short a low-power electrical circuit. Boeing Aircraft became interested and in its lab was able to detect whiskers thinner than 2 microns, and with a growth rate of $\frac{3}{8}$ in. per year on tin and tin alloys. (See page 81 for an article on selecting tin alloy coatings.) Boeing found these whiskers to have a tensile strength in millions of pounds per sq. in. They grew at temperatures as low as −319 F, and even in a vacuum. The growth is still not fully understood. Why the difference in whisker-growing activity? Why is tin so susceptible? Many laboratories are "whisker researching" for answers.

—Benedict A. Leerburger Jr.



The above chart shows the range of ultimate tensile strength over a period of one year's production. Average value obtained is approximately 150,000 p.s.i.

"e.t.d."™ Process Applied to FATIGUE-PROOF™ Steel Bars Gives Added Strength, Greater Uniformity, Better Machinability

Guaranteed 140,000 p.s.i. minimum tensile... no heat treating necessary

Six important physical and mechanical properties, (1) a high strength level, (2) exceptional uniformity, (3) improved machinability, (4) wear resistance, (5) resistance to fatigue, and (6) dimensional stability, are desirable features of La Salle "FATIGUE-PROOF" steel bars, produced by the new "e.t.d." (Elevated Temperature Drawing) process.

Strength . . . "FATIGUE-PROOF" is a carbon steel bar which replaces both hot-rolled or cold-finished carbon and alloy heat-treatable steel bars. Production figures show hardnesses between Rc 30 and Rc 36 (with a minimum hardness guarantee of Rc 30). The guaranteed minimum tensile strength is 140,000 p.s.i. with a 150,000 p.s.i. average.

"FATIGUE-PROOF" is better than a heat treated bar because it is not quenched and tempered and so the problems frequently associated with quenching and tempering such as (1) quench cracks, (2) non-uniformity of section, (3) soft centers, and (4) heat treat distortion are eliminated. Costly secondary operations such as grinding, cleaning, and straightening are not necessary. Rejects are minimized.

Exceptional uniformity... "FATIGUE-PROOF" is remarkably uniform from bar to bar, end to end, size to size, and lot to lot. Design and production engineers can depend upon it being the same from day to day and job to job.

Individual processing of each bar plus the inherent good qualities and characteristics of the "e.t.d." process account for the excellent uniformity. Microstructures are uniformly pearlitic.

Improved machinability... "FATIGUE-PROOF", made by "e.t.d.", machines 50% to 100% faster than heat treated alloys, and 25% faster than annealed alloy steels. It machines with a very fine finish, and gives excellent tool life. These characteristics make it an ideal steel for production parts.

Wearability . . . Field applications such as gears, pinions, pins, and screws prove that "FATIGUE-PROOF" has good wear resistance. It resists galling and seizure, partly due to its hardness . . . and probably due to the anti-weld characteristics of its chemistry. Further, "FATIGUE-PROOF's" pearlitic structure appears to resist sliding wear better than a quenched and tempered structure of equal hardness.

Resistance to fatigue . . . The chief reason for the failure of highly stressed parts is fatigue. While part shape, unfavorable residual stresses, tool marks, gouges in highly stressed areas, and many other factors contribute to fatigue failure, most materials have also an inherent quality . . . endurance limit that is an indication of ability to resist fatigue.

"FATIGUE-PROOF" has this inherent quality to resist fatigue. Laboratory tests prove that fatigue properties are at least comparable to those of expensive heat treated steels of the same strength level. Numerous field tests, under severe operating conditions, have proved this to the satisfaction of many manufacturers.

Dimensional stability... "FATIGUE-PROOF" maintains a high degree of dimensional stability in machining because of its low order of residual stresses.

Details of the e.t.d." process . . . Elevated Temperature Drawing involves (1) the selection of bar chemistry, (2) the amount of reduction in cross-sectional area of the bar as it is drawn through a special die, and (3) a preselected elevated drawing temperature which will result in the desired final properties.

Although the "e.t.d." process was first announced early in 1957, it has been used in the production of "FATIGUE-PROOF" steel bars since September 1955. Four U.S. Patents (Nos. 2,767,835, -6, -7, and -8) were granted October 23, 1956, covering the "e.t.d." process – an exclusive development of La Salle Steel Company.

How manufacturers can obtain sample Fatigue-Proof steel bars for testing

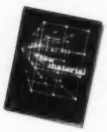
LaSalle Steel Company has announced that samples of "FATIGUE-PROOF" steel bars, made by the "e.t.d." (Elevated Temperature Drawing) process, are available for test purposes on a no charge basis to manufacturers where it appears that "FATIGUE-PROOF" can help improve products and reduce production costs.

Applications for a sample bar are invited from manufacturers making parts from either hot-rolled or cold-finished carbon or alloy steel bars which require high tensile strength.

Interested manufacturers may write for a test sample by sending a blueprint or application details direct to LaSalle Steel Company, Advertising Department, P. O. Box 6800-A, Chicago 80, Ill.

"FATIGUE-PROOF" is also available from your steel distributor . . . write for his name.

Brochure tells story of Fatigue-Proof steel bars



"A New Material" is the title of a 24-page booklet which gives detailed information covering La Salle "FATIGUE-PROOF" steel bars made by the Elevated Temperature Drawing process.

The booklet presents the results of more than one year's tests of production samples and reports on eight application case studies. Copies available on request.

TM—Trademarks of La Salle Steel Company

La Salle STEEL CO.

1430 150th STREET
HAMMOND, INDIANA

Developments

To Watch

ACTIVATED ATOMS AND SEMICONDUCTORS . . .

. . . go to work in a new "all-solid-state" photoelectric system being developed by Westinghouse engineers. They say it "combines much of the versatility of photoelectric control with the reliability of solid state components," and should "overcome a weak link—the light source—in the development of solid-state photoelectric limit switches, hot-metal detectors, and other kinds of position indicators."

As Paul Weisman and S. L. Ruby of Westinghouse demonstrated at an AIEE meeting last week, the isotope source (strontium 90) furnishes a beam of high-energy radiation that activates a cadmium sulfide photocell. The amount of ionization determines the change in resistance, and a transistor serves as amplifier.

It should be possible to produce the unit at moderate cost. The cadmium cell costs about $3.50, and only 50¢ worth of strontium 90 is needed.

AN AUTOPILOT FOR AUTOS . . .

. . . will be offered by Chrysler on 1958 models. It will link accelerator and speedometer to let the driver cruise at a preselected speed. The unit has a flyball governor, connected by a cable to the speed selector. To put the unit in operation, the driver presses a button recessed in the speed-selector knob which couples accelerator and governor linkages. A small, reversible electric motor supplies the power.

A NEW ROUTE TO NICKEL-ALUMINUM ALLOY PARTS . . .

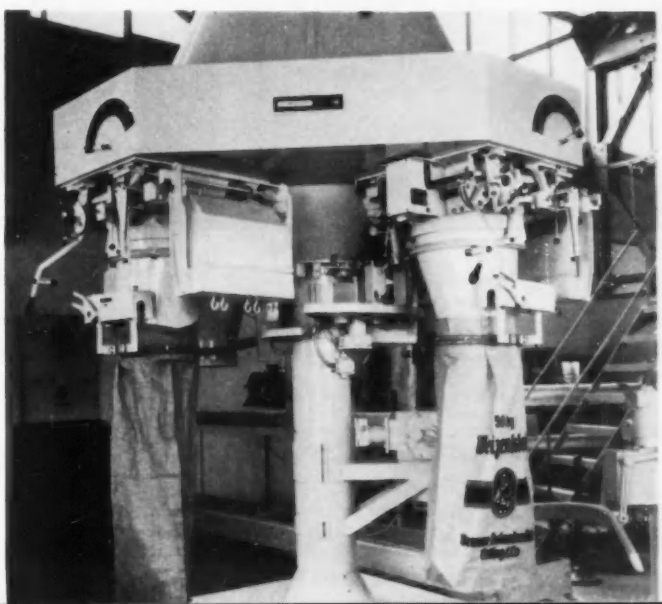
. . . is being explored in Germany. These alloys are known to have excellent resistance to heat and corrosion, but they are extremely difficult to melt and cast. Now, metallurgists at Siemens-Planiawerke AG, Meitingen, have developed an alloy powder that compacts at relatively low pressure, and can be sintered in hydrogen at 2100 F.

To produce the powder, a nickel-aluminum amalgam is formed under pressure at elevated temperature (about 930 F). Then, the alloy is precipitated—in a mercury suspension—and filtered. Densities of 95 to 99% are obtained, and an oxidation treatment can raise breaking strength as high as 40,000 psi at 930 F. Some of the alloys—80% Ni-20% Al, for instance—are said to show good strength and corrosion resistance in air up to 2350 F.

BAG-FILLING MACHINE . . .

developed by Greif-Werk Ernst Mahlkuch of West Germany, and introduced at the Hannover Fair (see also Oct. 21, p. 10), has a number of interesting features. Lifting mechanism is connected to bag clamp so one lever can simultaneously actuate bag-gripper and set weigher in motion. Filling speed can be regulated during operation (400 to 1000 bags an hour), and a limit switch actuates the take-off station. Like so many of the other new machines introduced at the Fair, it's produced in mobile as well as stationary models.

—A. R. G.

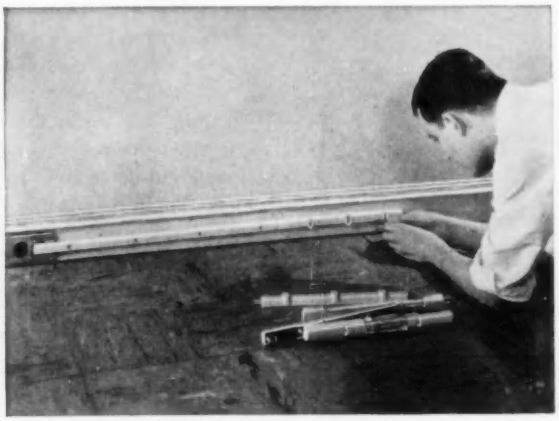


CYANAMID

PLASTICS NEWSFRONT

BABY-FEEDING WARE WITHSTANDS FREQUENT BOILING—AND BABY

Clever design and practical purpose are combined in the attractive baby-feeding ware and educational toys molded by North Star Industries of CYMAC® 400 polymethylstyrene molding compound. Thanks to CYMAC, all pieces are boilable—can be sterilized as often as necessary without distortion, cracking or discoloration. CYMAC upgrades products, provides better quality at competitive cost.



NEW LOW-COST ELECTRICAL OUTLET SYSTEM

Made from ivory-colored BEETLE® urea molding compound, these interlocking foot-long units provide low-cost, easily installed electrical outlets wherever they're needed. BEETLE's strength and excellent insulating properties guarantee safe, dependable service. Its hard smooth surface resists scratching and discoloration. Made by Cable Electric Products Inc., Providence, R. I., this new Snapit Inter-Link system is fully approved by Underwriters Laboratories Inc., a sure indication of its quality and safety.

PLASTIC DESK TOPS HERE TO STAY

"Not a single delamination caused by a faulty glue line" is the proud record of Desk Tops Inc., major supplier of school desk tops east of the Mississippi. URAC® 185 urea resin adhesive is used to bond hardwood plywood cores to rich CYMEL® melamine resin plastic surfaces. These resins are exceptionally strong and are fully resistant to moisture, heat and chemicals. Desk Tops Inc. guarantees tops against glue failure...will use no adhesive other than URAC 185.

AMERICAN CYANAMID COMPANY
PLASTICS AND RESINS DIVISION
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In Canada: North American Cyanamid Limited, Toronto and Montreal

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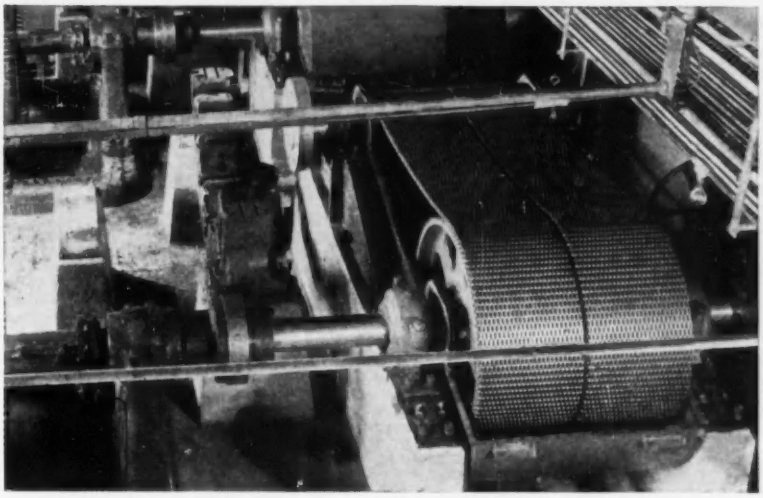
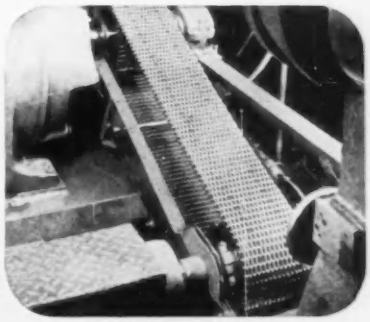
CYANAMID Plastics and Resins Division
MATERIALS FOR TOMORROW

How LINK-BELT silent chain comes through industry's stiffest tests

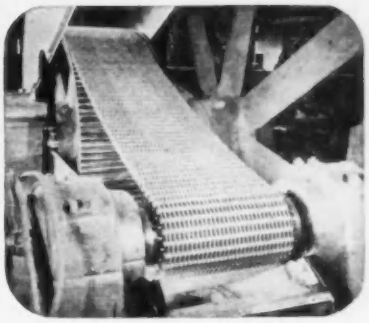
No other drive can do the same



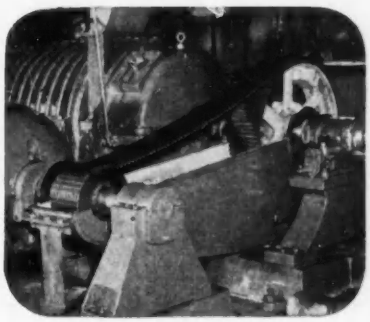
LARGE OR SMALL HP. Two 24-in. strands of Link-Belt silent chain on turbines powering 850-kw generators comprise one of the largest chain drives ever built. Silent chain provides high efficiency (over 98%) on large or fractional hp drives.



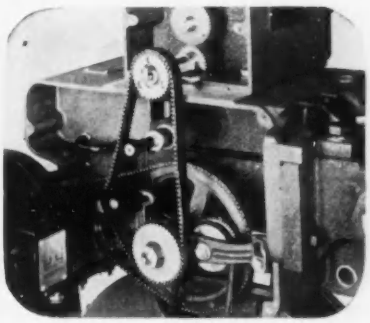
HIGH SPEED. Link-Belt silent chain drives on newspaper presses often operate at speeds of 4000 to 5000 feet per minute.



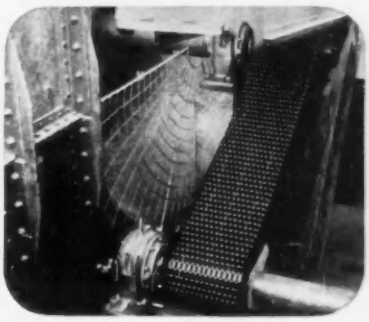
ADVERSE OPERATING CONDITIONS. Effects of heat, humidity and cold are minimized with Link-Belt silent chain drives.



LARGE RATIOS. Link-Belt silent chain operates efficiently at ratios as high as 10-to-1, with resulting space economies.



LIMITED SPACE. A complete drive as small as your thumb—Link-Belt 3/16-in. silent chain is ideal for limited-space applications.



LONG LIFE. Link-Belt silent chain has given more than 30 years of uninterrupted service on ventilating systems.

Get in touch with your nearest Link-Belt office for

88-page Data Book No. 2425

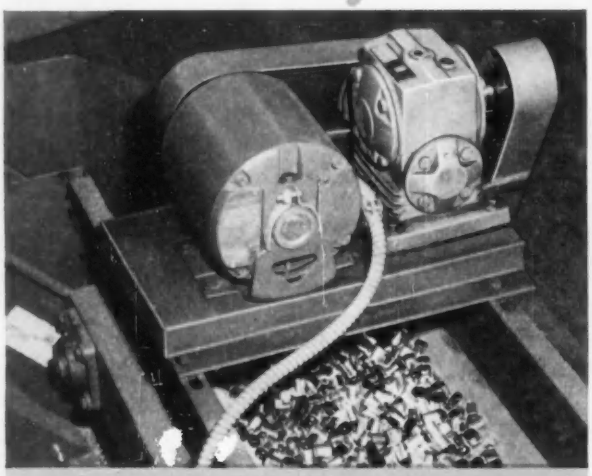
LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.680-A

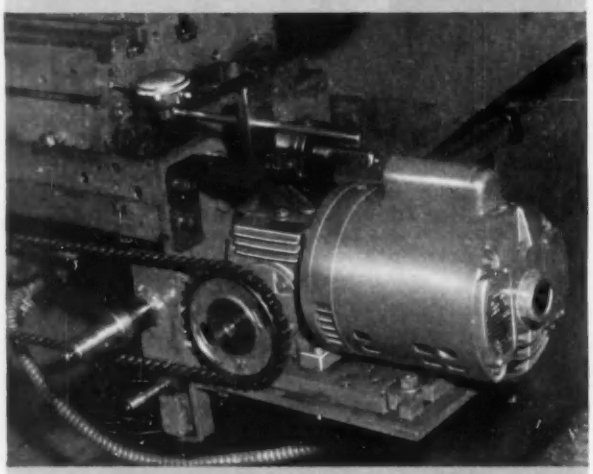
Cost-wise design calls for STANDARDIZED BOSTON Gear SPEED REDUCERS

FROM STOCK!

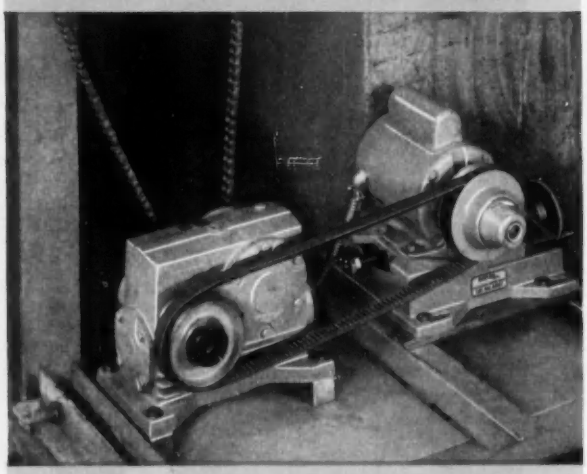


LASTING POWER ECONOMY, long wear, easy maintenance and quiet operation make Boston Gear Speed Reducers the practical choice for drives in materials handling equipment. A 100 Series Model T Reductor is used in the conveyor drive illustrated, where production of 4,000,000 lamp bases per day requires continuous, trouble-free operation.

COST OF SPECIAL MACHINES IS MUCH LESS when designed around Boston Gear standardized stock components. A 100 Series Model VMW Ratiomotor drives this automatic stripping and soldering machine for fuse plug lead wires. Assembly also includes standard stock Boston spur gears, rack, pillow blocks, pulleys, sheaves, and bushings.



INCREASED COOLING EFFICIENCY of the finned housings of Boston Gear Speed Reducers dissipates heat rapidly. This permits compact design and higher torque capacity, of special advantage in machine tool drives like the 100 Series Model M Ratiomotor illustrated, and where space is limited, or where high area temperatures prevail..

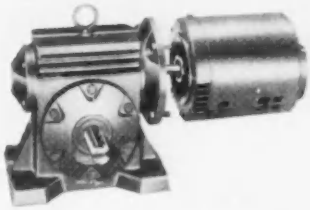


STANDARDIZED VARIABLE SPEED DRIVES, assembled from Boston Gear stock parts, simplify the design job, and save the time required to procure special equipment. The illustration shows a Boston Gear Variable Speed assembly with a Type TW Reductor, used with Boston stock sprockets and chain to drive conveyor belt of a heat-treating furnace.

Since Boston Gear *standardized* Speed Reducers take top-rating in any comparison — why pay more, why wait for "specials"? Your nearby Boston Gear Distributor can deliver any model you need, *from stock.* His factory-trained specialist will furnish any information you need to simplify drive design and assure lasting economy. Be cost-wise . . . STANDARDIZE and SAVE. Boston Gear Works, 71 Hayward St., Quincy 71, Mass.

DETACHABLE MOTOR DESIGN OF BOSTON Gear 100 RATIOMOTORS

permits motor change in minutes continued operation with spare.

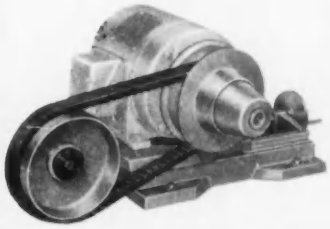


The standard end-mounted motor on all 100 Series RATIOMOTORS is easily detachable — can be changed quickly and easily. The gear assembly remains undisturbed, so no realignment is required.

The detachable motor design also makes any 100 Series RATIOMOTOR readily adaptable to changing conditions of operation. You can easily replace the original motor with other types . . . totally-enclosed, explosion-proof, etc.

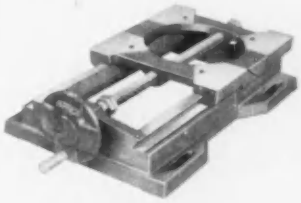
With today's production demands, you need the most dependable protection against downtime losses. Design around Boston Gear RATIOMOTORS and make this easy maintenance feature a money-saving advantage of your assemblies.

NOW — BOSTON VARIABLE SPEED DRIVES — FROM STOCK



For use with ½ and ¾ HP motors to provide constant torque, infinitely variable, 3 to 1 speeds — in any range between 1750 RPM and .5 RPM. Assembly of STANDARD STOCK parts includes adjustable Motor Base, self-contained, spring-tension Motor Pulley, flat driven Pulley, and heavy duty Belt.

BOSTON VARIABLE SPEED REDUCTOR DRIVES consist of above parts with addition of a 100 Series REDUCTOR — Type V, TW, V, or VW.



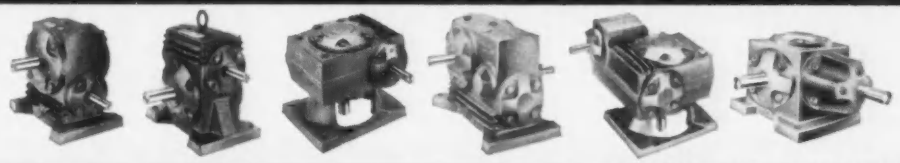
ADJUSTABLE MOTOR BASE

CALL YOUR BOSTON Gear DISTRIBUTOR

See Catalog No. 56 for complete specifications and selection data.

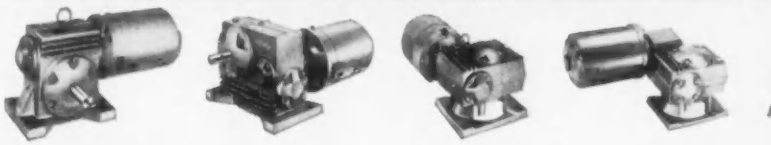
1605 TYPES and RATIOS **FROM STOCK** AT FACTORY PRICES

REDUCTORS Ratios 1:1 to 3600:1 .004 to 50 HP

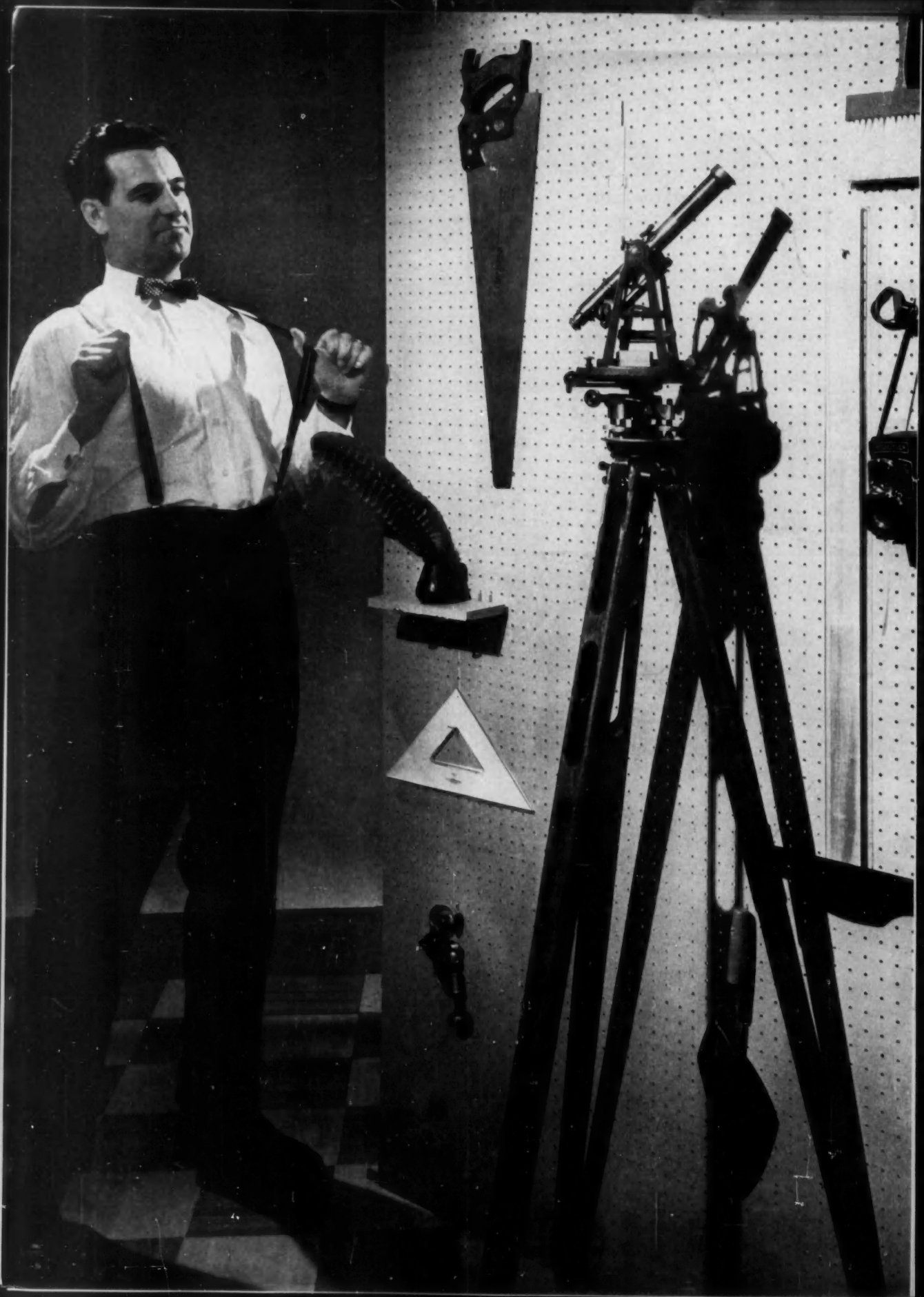


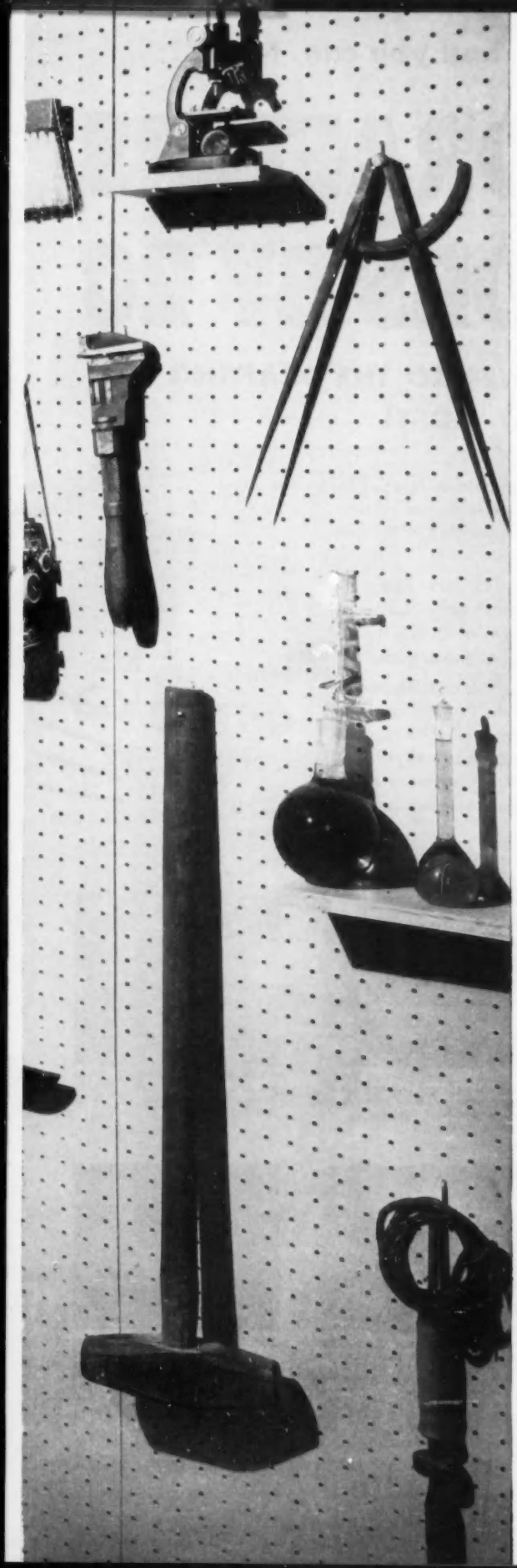
RATIOMOTORS Output RPM .49 to 175

FLANGED REDUCTORS



Gear assemblies of Ratiomotors, sold without motors. You buy and attach your choice of motor.





Can a man be an expert in everything?

IT'S SAD BUT TRUE that the product design engineer of today has to be a many-faceted expert. He has to be an engineer *and* a materials expert *and* a production expert. He has to be well up on purchasing fundamentals, plus the elements of cost accounting.

There is one design responsibility from which we can give you some relief, though. That is the selection of springs. Spring design is a field unto itself, and, although we'll be glad to give you mountains of interesting information on the subject, why concern yourself with it? We'll do the work for you.

AS&W spring engineers will gladly work with you to select the right combination of spring characteristics that will do the job well. Most important: they may be able to suggest a slight design change that will drastically lower the *cost* of the spring.

Just call your nearest AS&W representative.

AMERICAN STEEL & WIRE DIVISION
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GENERAL OFFICES: CLEVELAND, OHIO
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USS AMERICAN *QUALITY* SPRINGS

UNITED STATES STEEL

USS

"I proved it to myself... and you can, too...

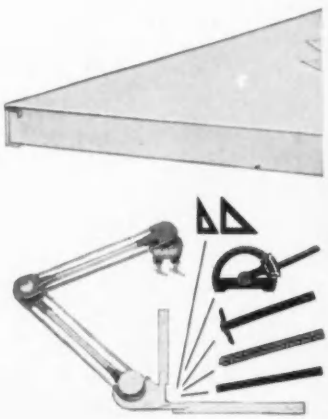
"BRUNING DRAFTERS DRAFTING JOBS BY 20

BRUNING DRAFTERS ADD MANPOWER TO THE DRAFTING ROOM — NOW WHEN YOU NEED IT MOST!

DRAFTSMEN! Prove it to yourself as have hundreds of skeptics who once frowned on using anything but conventional drafting tools like the T-square, triangle, and protractor. Bruning drafters actually speed drafting up to 40% on most jobs, up to 50% on some structural drawings . . . make your work far easier.

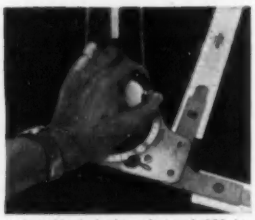
DEPARTMENT HEADS! The boom in production means pressure for more and more engineering drawings. With drafting space at a premium and experienced draftsmen hard to get, you couldn't find a faster or better way to add "manpower" than by boosting the output of your present draftsmen with modern, efficient Bruning drafters.

BRUNING DRAFTERS SPEED DRAFTING because they combine T-square, straightedge, triangle, protractor, and scales in *one* precision instrument. You eliminate the time and effort previously diverted to lifting, sliding, replacing, and reaching for these separate tools. Easily and quickly, you rotate, turn, and lift your Bruning drafter—all with the left hand. With fast fingertip control, you set and lock scales to any base line or angle. You accomplish everything that you can do with the conventional five basic instruments—only you do it much faster and much more accurately!

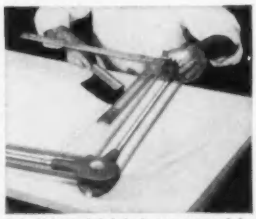


WHY BRUNING DRAFTERS ARE EASY TO OPERATE!

Bruning design permits complete 360 degree rotation about both the head and mast, making all parts of the board easily accessible—scales remain parallel to original angle setting. Patented Equipoise mechanism counteracts gravity on slopes up to 15°, literally "floats" your drafter into place without sag or "kickback." Exclusive Scalock device makes it easy to change scales, holds scales rigid while in use.



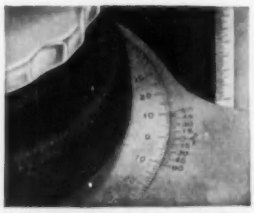
Automatic indexing stops at 15° intervals are engaged and released by just a press of the button on Bruning's unique Touch Control.



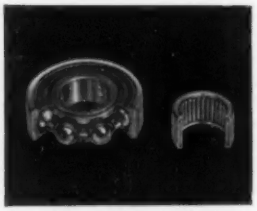
A ball-type joint between arms lets you lift your drafter over objects without unbalancing the machine or disturbing alignment of scales.

WHY BRUNING DRAFTERS ARE TOPS IN PRECISION AND DURABILITY!

Protractors have engine-divided graduations and double verniers reading to an accuracy of 5 minutes on most Standard models, to one minute on Civil Engineer models. A mathematically precise system of pulleys, machined to a tolerance of 0.0002", assures that drawing edges remain absolutely parallel to their original angle setting. Sturdy construction of the finest materials insures lasting accuracy and trouble-free operation.



Protractor and vernier graduations are set flush in the same plane to eliminate parallax error. Easy-to-read graduations are engine divided for accuracy.



Class #1 precision-ground, permanently lubricated ball bearings and frictionless needle bearings assure accuracy, effortless operation, and long life.

SPEED TO 40%!"

BRUNING

EQUIPOISE

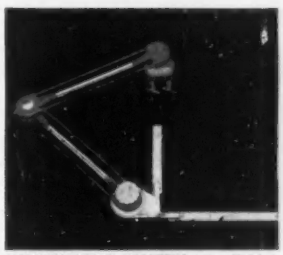
DRAFTING MACHINES

Exclusive Equipoise gravity compensator—finest on the market—permits use of drafter on inclined boards.

Standard protractor models—for mechanical, architectural, and structural draftsmen—are equipped with automatic indexing stops at 15° intervals. Civil Engineer protractor models—for civil, municipal, and utility engineers—have an azimuth scale, magnifier, and micrometer adjusting wheel. Arm lengths available to cover board areas from 36"x60" to 48"x96". Wide variety of scales. No extra charge for left handed models.

BRUNING TRACK DRAFTERS bring new space-saving efficiency and accuracy to firms that need extra-large drawings. Both single-arm and double-arm models offer automatic indexing, double verniers, and fast scale changes. Models are available to provide vertical coverage up to 84", unlimited horizontal coverage.

BRUNING COUNTERBALANCED DRAFTERS provide unusual speed, and accuracy in vertical drafting. Available with Standard or Civil Engineer head and same arm lengths as Equipoise drafters.



BRUNING DETAIL DRAFTERS are a lighter, more compact, and less expensive variation of larger Bruning machines. Ideal for smaller drawings and use in shops, schools, and in the field.

BRUNING

America's Leading Supplier of Engineering and Drafting Equipment

Offices in 38 Cities of the U.S. and Canada

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4700 MONTROSE AVENUE, CHICAGO 41, ILLINOIS

In Canada: Charles Bruning Co. (Canada) Ltd., 105 Church St., Toronto 1, Ont.

Charles Bruning Company, Inc., Dept. 104-O
4700 Montrose Ave., Chicago 41, Illinois

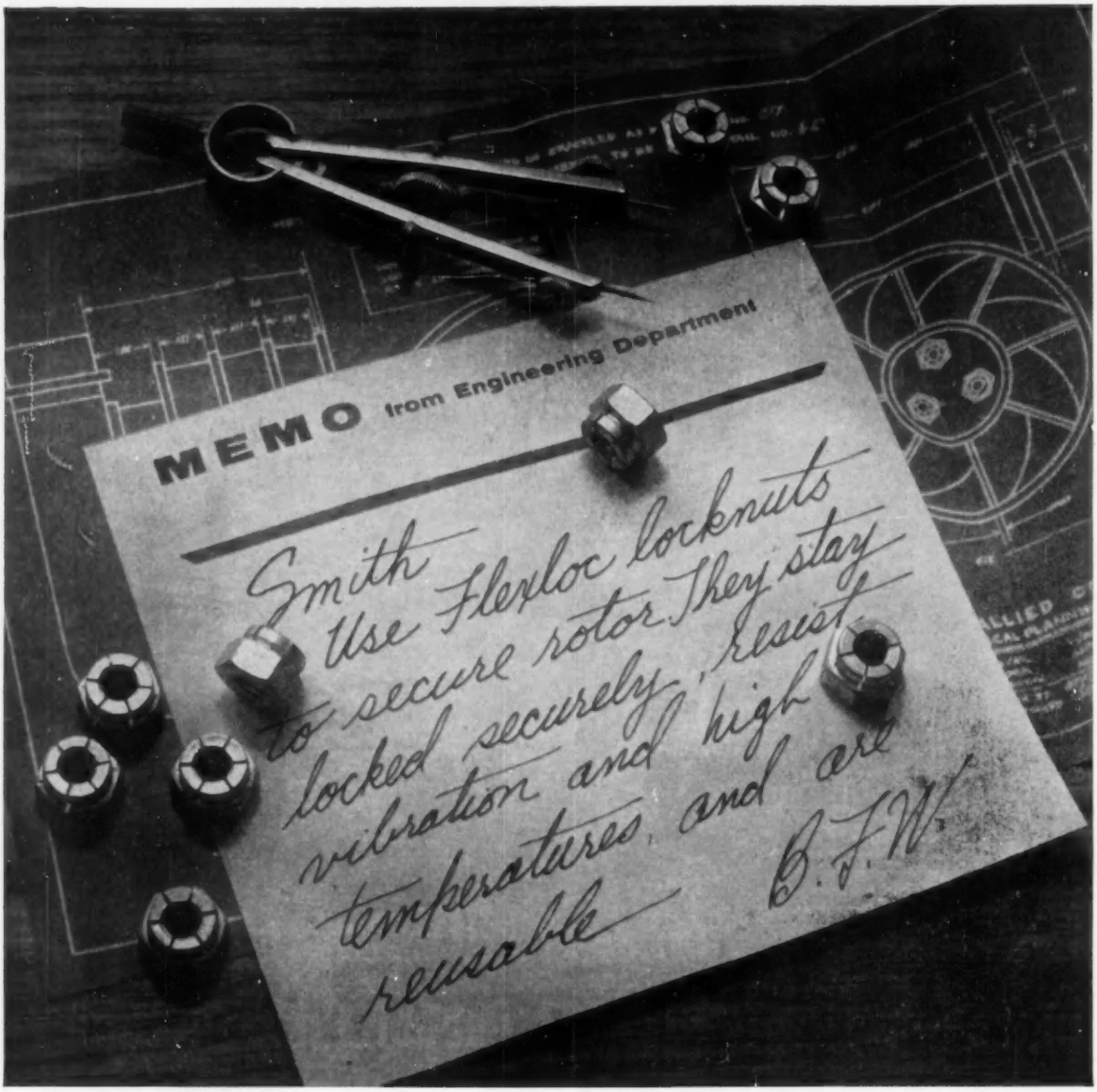
Please send me the free, 20-page booklet on Bruning drafting machines.

Name_____ **Title**_____

Company_____

Address_____

City_____ **County**_____ **State**_____



Vibration won't loosen FLEXLOC self-locking nuts

Where products must be reliable . . . must stand up under vibration, temperature extremes and hard use . . . designers specify rugged, reliable, precision-built FLEXLOC self-locking nuts.

HERE'S WHY:

FLEXLOC locknuts are strong: tensile strengths far exceed accepted standards. They are uniform: carefully manufactured to assure accurate, lasting locking action. And they are reusable: repeated removal and replacement, frequent adjustments, even rough screw threads will not affect their locking life.

Standard FLEXLOC self-locking locknuts are available in a wide range of standard sizes, types and materials to meet the most critical locknut requirements. Your local industrial distributor stocks them. Write us for complete catalog and technical data. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 28, Pa.

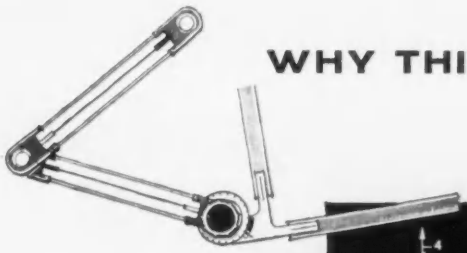
We also manufacture precision titanium fasteners. Write for free booklet.

FLEXLOC® LOCKNUT DIVISION

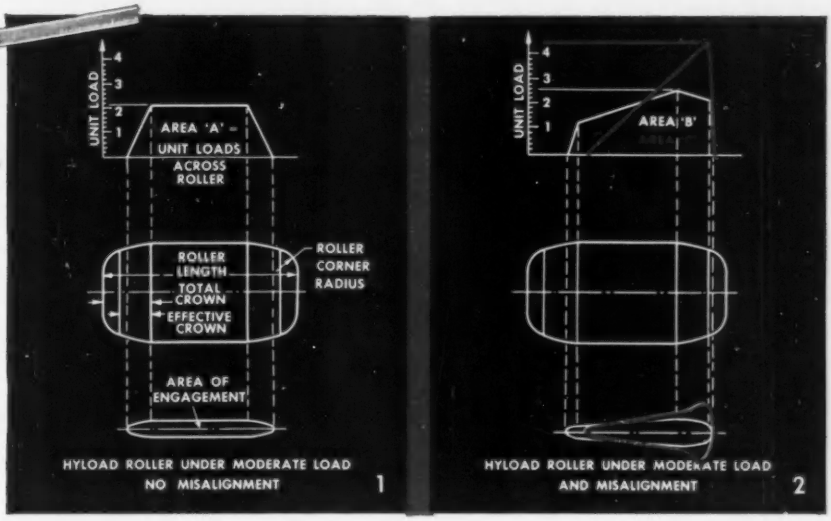
STANDARD PRESSED STEEL CO.

SPS

JENKINTOWN PENNSYLVANIA



WHY THINGS RUN SMOOTHER WHEN YOU SPECIFY HYATTS



HY-LOAD ROLLER CROWNING MINIMIZES EFFECTS OF MISALIGNMENT—LENGTHENS BEARING LIFE

In any roller bearing, the design and quality of the rollers themselves vitally affect the performance of the entire bearing. The distribution of the load across the roller's full area of contact must be carefully controlled. End-loading and conditions of misalignment can seriously reduce the life of a roller bearing. How HYATT minimizes these effects is detailed at the right.

You will find full selection and application data in HYATT Catalog 150, or call your nearest HYATT Sales Engineer. Hyatt Bearings Division, General Motors Corporation, Harrison, N.J., Pittsburgh, Detroit, Chicago and Oakland, California

The unit load on any roller is distributed axially in a uniform manner except at the ends where crowning has been provided. Figure 1 shows how the unit load drops off to zero at the ends of the area of contact. The summation of unit loads represented by area "A" is the total roller load. This same load under conditions of misalignment (Figure 2) must result in an area "B" equal to area "A"; but the maximum unit load is considerably greater and the misaligned bearing will therefore have a shorter life. However, if the same total load is applied to an uncrowned roller in a misaligned bearing, as shown in red, a much higher maximum unit load (area "C") results, and would reduce the life of the bearing. This demonstrates why HYATT Hy-Load Series Bearings with roller crowning run smoother and longer even under conditions of misalignment.

THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

GM GENERAL MOTORS

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

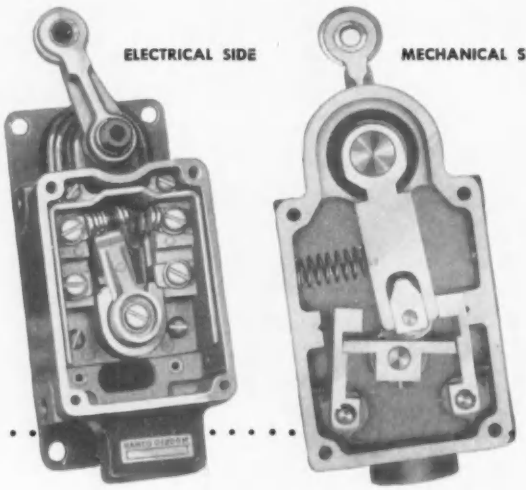
PROVED . . . by millions of contacts

NATIONAL ACME SNAP-LOCK TRADE MARK

As illustrated below, National Acme SNAP-LOCK Limit Switches employ a basically simple yet positive *snap-action* locking mechanism—with extremely few moving parts. Thus wear is reduced to a minimum and dependable trouble-free service, far beyond normal limits, is assured.

The double-throw contact lever, connected directly by shaft with the latch bar, carries self-wiping coin silver contact points to assure quick action make or break—reducing wear ever further.

Electrical and mechanical sides are separated by a wall within a sturdy die-cast housing which is fully insulated and is dust and oil-tight.



THE ORIGINAL SNAP-ACTION LOCKING SWITCH

SNAP-LOCK LIMIT SWITCHES. Made in single-pole and double-pole series, in four types: Standard, Short Travel, Neutral Position and Push Lever. With the exception of the Push Lever Switch, all are adaptable to special enclosures for hazardous location service and may be used with various styles of operating levers. For AC or DC service.

and now . . .

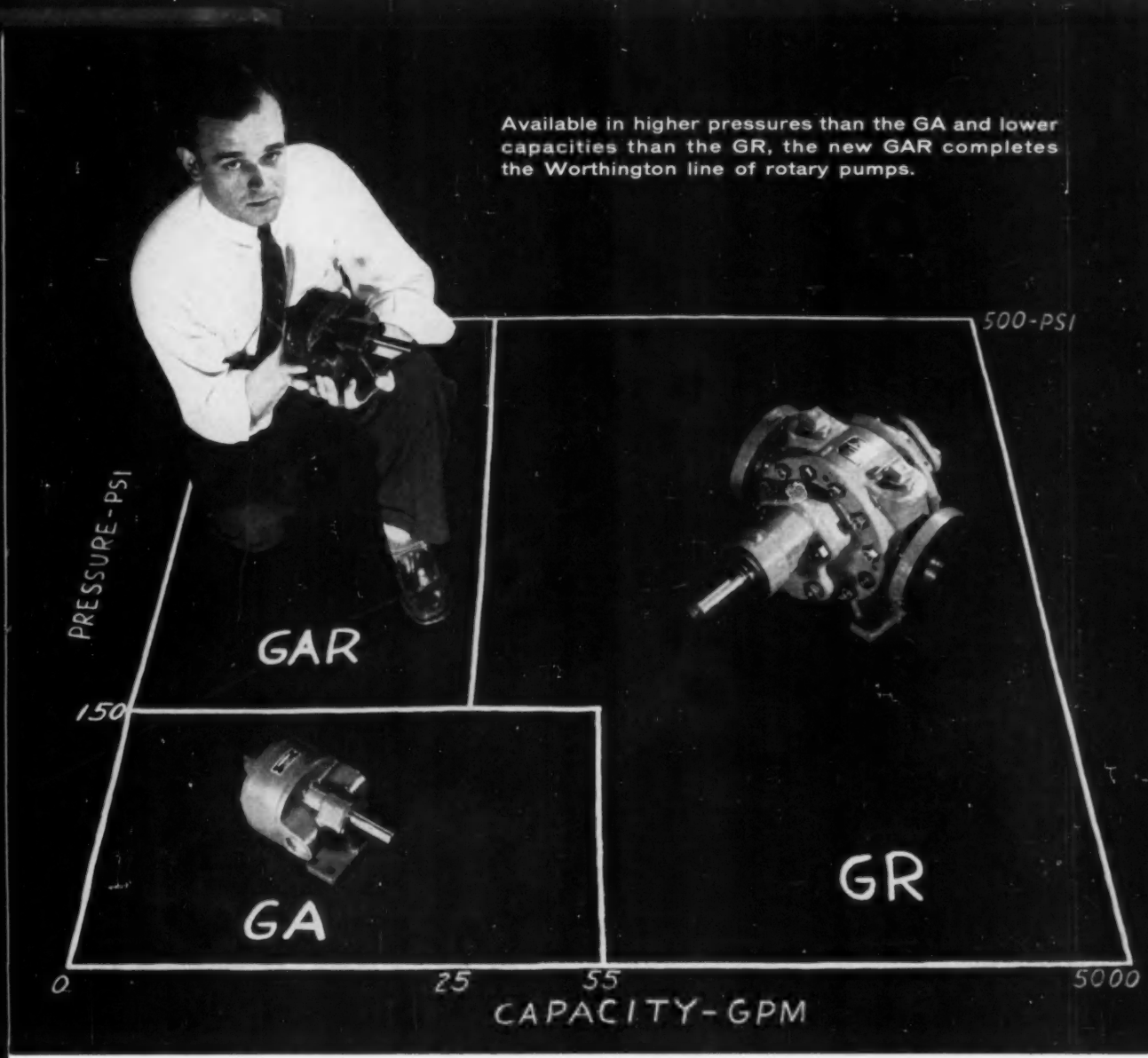
a new design concept for **CONTROL STATION SWITCHES**
the heavy-duty . . . oil, water, dust tight **GOLD-N-RING**
made by machine tool builders to machine tool specifications

Heavy duty silver-alloy contact points provide maximum electrical capacity, long life.
Heavy duty terminal screws have ⅜" thread contact to prevent stripping during installation and permanently secure wires for continuous, trouble-free service.
Single or double-pole contact block assemblies—can be used interchangeably with several types of GOLD-N-RING push button and selector operator heads.
Rated for 600 volts—AC or DC. Meets all Joint Industry Committee and National Machine Tool Builder's Association requirements.
Protected against oil and water seepage in operator head by Sealtight oil-resistant rubber diaphragm.
Easily replaces existing switches.

ELECTRICAL MANUFACTURING DIVISION

the National Acme company

170 EAST 131st STREET, CLEVELAND 8, OHIO



NEW ROTARY PUMP

offers new economy in high pressure, low capacity range

Why sacrifice space, economy, and efficiency in high pressure, low capacity pumps? Here is a new line of internal roller bearing, herringbone gear pumps, designed for continuous operation up to 500 psi in capacities to 25 gpm.

The new Worthington GAR pump is a flexible, rugged unit which provides long trouble-free service. Available in either foot-mounted or Monobloc design, it features heavy-duty, hardened steel roller bearings, nodular iron, double helical gears, and steel backed bronze filler plates which set it apart from the field.

The new GAR is just one of Worthington's complete line of rotary pumps—broadest on the market. Worthington offers 142 different standard rotaries to choose from plus many optional features such as mechanical seals and relief valves. Each pump is factory tested before shipment.

Preferred by users everywhere, Worthington rotaries are backed by service outlets throughout the country. See your Worthington representative for more information or write for descriptive bulletins. Address Section SP-74, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955 Ltd., Brantford, Ont.

WORTHINGTON

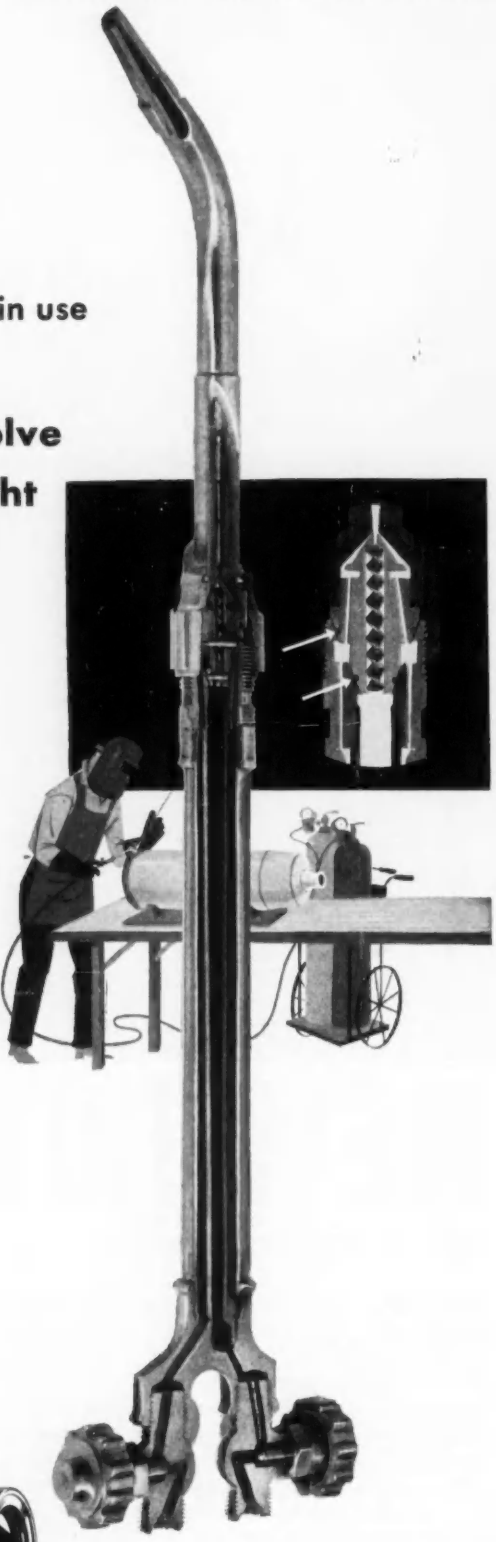
Ozone deterioration

Continuing stress

Gas leakage

Rough handling in use

New National Hypalon O-rings solve these problems; insure a hand-tight gas seal in Victor Torches



As static seals, commercial Buna N O-rings performed satisfactorily in Victor welding torches — *when the rings were new.*

However, ordinary O-rings age fast in welding torches. They receive rough treatment when welders change nozzles; nozzles are often dropped on the ground to lie there until needed again. Severe ozone deterioration is experienced. Continuing stress, although mild, impairs O-ring elasticity. Rings on welding nozzles are sometimes subjected to long shelf life.

National Seal engineers developed a new O-ring compound, National Hypalon L-11, which not only withstands rough handling, ozone deterioration and stress but exhibits many times the shelf life of Buna N compounds previously used. Today, National Hypalon is standard at Victor.

Special compounding to meet unusual conditions is a basic part of National's complete O-ring engineering service — service available from National Field Engineers in major cities nationwide.

NATIONAL SEAL
Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California
Plants: Van Wert, Ohio, Redwood City and Downey, California

4374

WHY WEIRZIN®?

"*It resists rust, forms easily and holds paint.*"

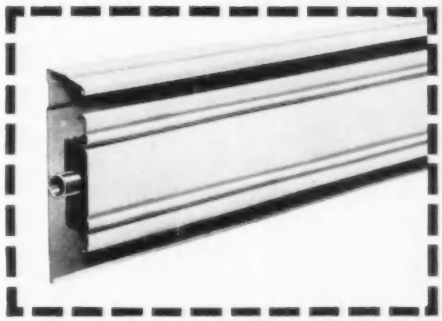
So reports the Vulcan Radiator Company, Hartford, Connecticut.

"*We must bend Weirzin electrolytic zinc-coated steel like a pretzel in producing our high quality Trimline baseboard radiators. Weirzin goes right along with us—doesn't balk one bit. Our finished baseboard radiators have a constant flow of bends and turns. But in forming them, not one speck of Weirzin's protective zinc coat flakes or peels off. This assures us that recoating of our radiators is a thing of the past and that rust is a real 'goner' having no bare steel to feed upon. And, chemically treated Weirzin takes and keeps paint as if it were the natural thing to do. A decided advantage over other metals that can 'take' paint but don't hold it all.*"

That's Weirzin electrolytic zinc-coated steel sheets! They never give rust a start, thereby eliminating any future corrosion problem. They have a natural paint bonding surface which means the end product has a beautifully painted finish that will fit into any décor. They have the strength of their steel base which means a longer life of worry-free service.

What better characteristics could any product have to meet the exacting demands of manufacturers everywhere.

See how Weirzin can meet your requirements—better! Just write Weirton Steel Company, Dept. **D-26,** Weirton, West Virginia, for your free informative booklet.



WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

WEIRTON, WEST VIRGINIA

a division of

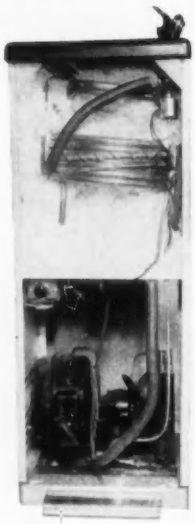
NATIONAL STEEL CORPORATION

UNIFLOW SWITCHES TO RUBATEX TUBING FOR SWEAT-PROOF INSULATION AT LESS COST

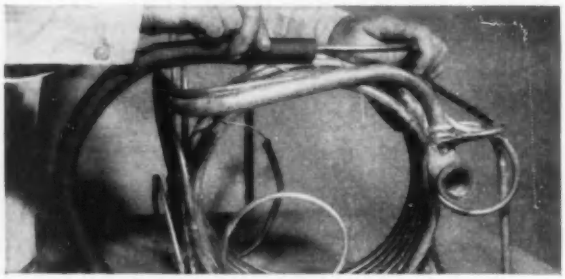
Cold lines in six Uniflow water cooler fountain models and ice cube maker now insulated with this new closed cellular rubber tubing insulation.

"We find Rubatex particularly applicable to our uses mainly because it doesn't absorb water and at the same time provides the insulation necessary at the points where it's used. We also believe Rubatex will last longer. *Lower initial cost and fast deliveries* were additional influencing factors in our switch to Rubatex."

L. E. Green, Chief Engineer
Uniflow Manufacturing Company
Erie, Pa.

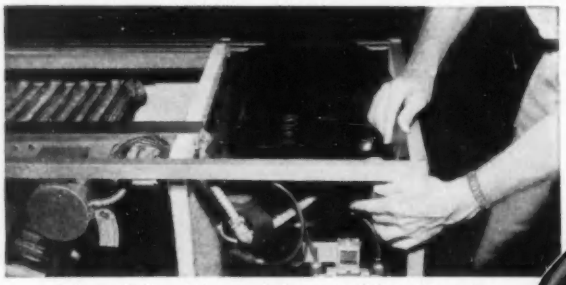


Interior of a Uniflow fountain showing Rubatex as insulation on cold water line where it passes close to outside skin of fountain—thus preventing "sweating" of cabinet. Also refrigeration line where Rubatex Tubing prevents condensation and resultant "puddling" on floor.



See how easily Rubatex is slipped on the Uniflow cold water line. Rubatex is especially adaptable where carriers are curved. Will readily bend without cutting or fitting—fits snugly to any contour of pipes.

Rubatex's unique nitrogen-filled closed cellular rubber structure makes it resiliently soft and most adaptable as formed copper tubing insulation for any cold lines requiring sweating resistance . . . cannot absorb water . . . keeps pipes forever dry . . . eliminates any need for additional vapor barrier . . . gives it excellent weather-aging characteristics . . . plus unusually good fire-safe thermal insulation properties. What's more—initial cost of new Rubatex Tubing Insulation is surprisingly low and *deliveries can be made fast!*



Rubatex Tubing being applied to one of the refrigeration tubes in Uniflow "Kold-Draft" ice cube maker. After inserting Rubatex over tube, an air hose is used to easily speed-up installation.

Available in standard inside diameters of 1/4" to 2" with 3/8" and 1/2" wall thickness. Other sizes can be made to specification. Produced in any lengths up to 250 feet. Can be slit for installed piping.

RUBATEX
CLOSED CELLULAR RUBBER
TUBING INSULATION

RUBATEX DIVISION, Dept. P-3
GREAT AMERICAN INDUSTRIES, INC.
Bedford, Virginia

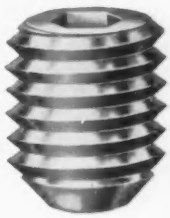
PIONEER MANUFACTURER OF CLOSED CELLULAR RUBBER

For full details and sample of Rubatex Closed Cellular Rubber Tubing—print your name in space below, attach to your company letterhead and mail to us.

Name _____

Send for Free Sample and full details

how to keep costs down



...profit margins up!

ALLEN Engineers will show you how you can save time and money by using standard* ALLEN Hex-Socket Cap and Set Screws instead of specials.

Let's get this straight right away... if your product design MUST have special cap or set screws, then ALLEN's the place to come for them.

But our engineers have found, from a good many years of experience, that designs frequently call for *special* hex-socket cap and set screws that are only slightly "off-standard." These specials take longer to get, cost more.

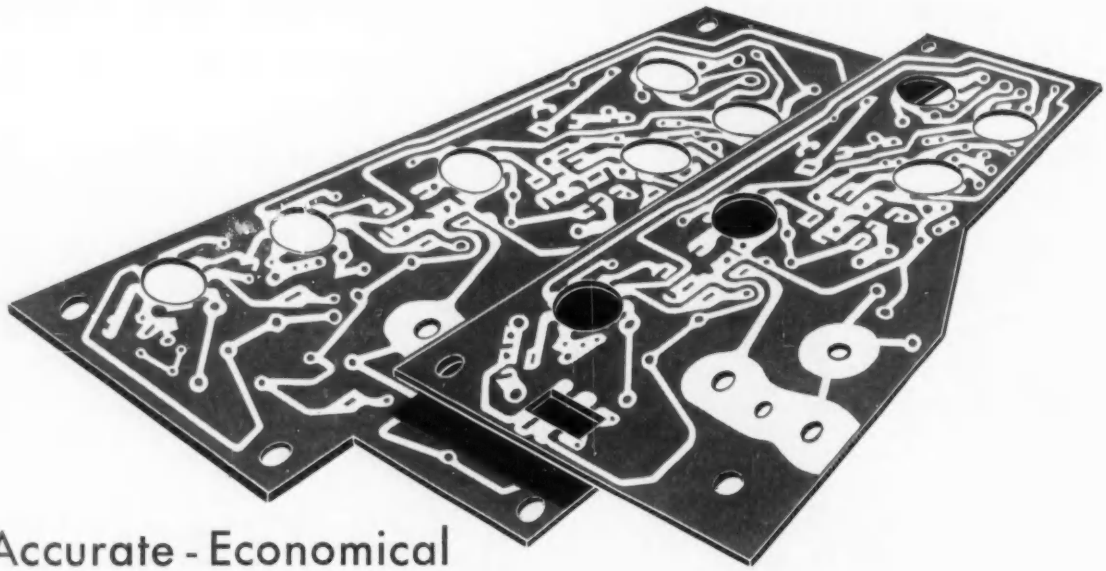
Allen engineers can probably save *you* both time and money by working with you on ways to use *standard* Allen Hex-Socket Cap and Set Screws, where specials may seem to be necessary. Just send blue prints, or good descriptions, of your product designs to our Engineering Department, or talk with your Allen Field Representative.

***ALLEN manufactures 1457 *standard* items**

Stocked and sold by leading industrial distributors everywhere

ALLEN MANUFACTURING COMPANY
Hartford 2, Connecticut, U.S.A.

ALLEN HEX-SOCKET SCREWS HEAD



Accurate - Economical

Printed Circuitry with Richardson INSUROK® XT-896

NEW Low temperature punching copper-clad laminate

XT-896 punches clean and sharp at room temperatures. Eliminates the problem of dimensional changes encountered in hot punching laminates. Tool and die planning and production are simplified because shrinkage is not a factor. Accurate punching also effects savings in mechanical assembly as well as in printed circuitry.

The dielectric constant of XT-896 is low and extremely stable under changing temperatures. This makes it ideal for circuits and components where "drift" is undesirable.

Richardson has a complete line of NEMA and special grades which meet virtually all electrical and/or mechanical needs of industry. For more information, write or phone Chicago—MAnsfield 6-8900.

Since etching can degrade laminates, Richardson publishes only average properties after etching. This reflects the normal conditions you would find in the use of printed circuits.

CHARACTERISTIC PROPERTIES

(Values shown are average)

	Cold punch XT-896 After Copper-clad etching	Hot punch T-725 After Copper-clad etching	Hot punch T-812 After Copper-clad etching
Thickness tested	1/16"	1/16"	1/16"
Water absorption	0.46%	0.40%	0.53%
*Power factor	0.027	0.030	0.029
**Power factor D/24/23	0.033	0.031	0.031
*Dielectric constant	3.71	4.2	4.5
**Dielectric constant D/24/23	3.86	4.3	4.6
*Loss factor	0.102	0.126	0.131
**Loss factor D/24/23	0.127	0.134	0.142
Insulation resistance Megohms C/96/40/90†	1,000,000	125,000	290,000
Flexural strength Lengthwise	14,000	19,000	19,500
Crosswise	12,000	15,000	15,500
Bond strength lbs/in Copper to laminate	7	8	8
Blister resistance Seconds at 450°F.	15	20	18

*Room conditions 50% RH @ 23°C.
**After immersion in water for 24 hours at 23°C.
†After conditioning for 96 hours at 40°C at 90% relative humidity.

RICHARDSON PLASTICS
LAMINATED and MOLDED

The RICHARDSON COMPANY
Founded 1858

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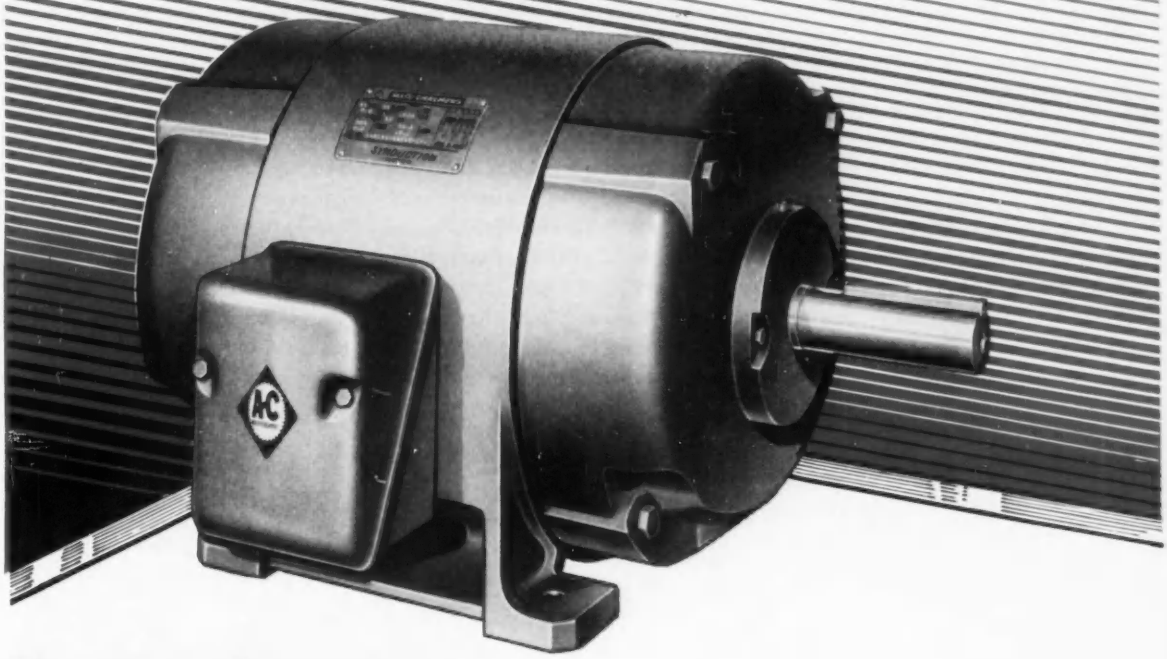
NEW *Synduction* MOTOR



Do you have an Application Requiring . . .

. . . **Constant speed, regardless of load or voltage, depending only on frequency.**

. . . **Synchronized speed for a number of motors.**

. . . **Adjustable speed with minimum variation at any speed setting.**

Synchronous Speed with Induction Simplicity

Allis-Chalmers new development — the *Synduction* motor — offers these characteristics at low cost — with the dependability of an induction motor. In addition to constant speed from no load to pull-out, it also offers across-the-line starting, wide range of speeds and high efficiency. It's another example of MORE motor pioneering by Allis-Chalmers.

Allis-Chalmers invites your inquiry, in the belief that many processes can be improved by the application of *Synduction* motors. Our engineers will gladly analyze your present operations to help you determine where *Synduction* motors can be applied profitably. Call your A-C office or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin, for Bulletin 51B8440.

Synduction is an Allis-Chalmers trademark.

A-5115

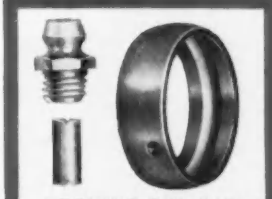
ALLIS-CHALMERS

60 YEARS OF SPECIALIZATION MAKES

Moline *chain*

best by any job test

MOLINE makes just one thing—the world's finest malleable chain. The superiority of this chain has been established by 60 years of specialization. Moline engineers and technicians confine their efforts to improving design and refining manufacturing techniques—to produce chain that will give maximum efficiency . . . trouble-free performance . . . long life. And only Moline chain is triple-tested. That means Moline chains undergo rigid physical testing, visual inspection and gauging by experts. Then, after assembly, they are stressed to proof strength and shock tested for soundness. Be sure to *specify Moline Chain*, malleable or promal, for conveying, elevating and power transmission services. Write today for catalog.

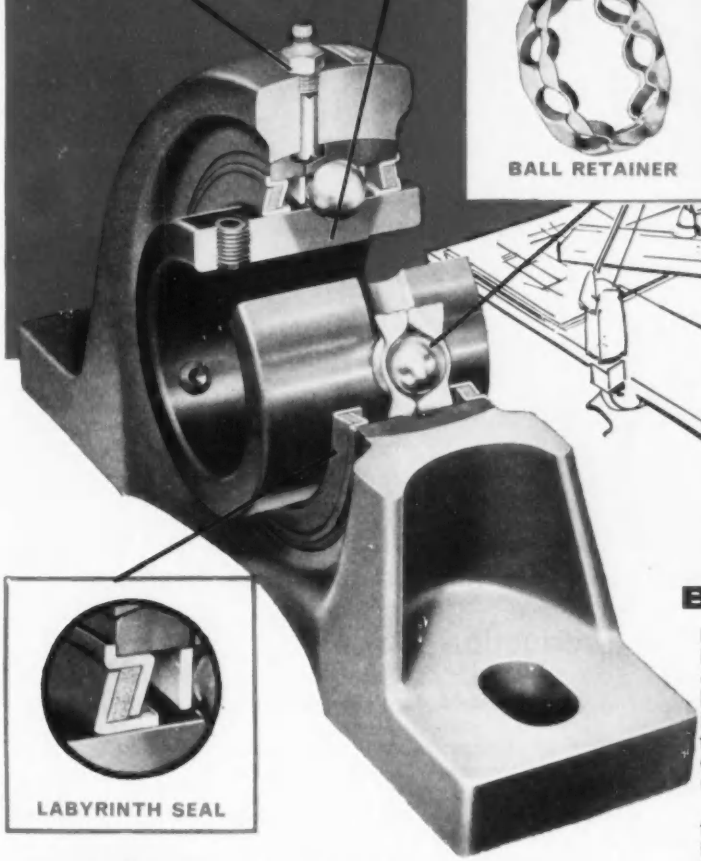


LOCKING PIN AND PERIMETER DIMPLE

ZONE HARDENING

Engineering that stands out... performance that stands up!

BALL RETAINER



LABYRINTH SEAL

SEALMASTER®

BALL BEARING UNITS

Here in the engineering department of SEALMASTER, many advanced features have been developed that have made SEALMASTER Ball Bearing Units the quality leader in the bearing field. These features not only provide a distinct advantage for SEALMASTER, they offer equal benefits for the original equipment manufacturers we serve.

Zone Hardening for example, means positive race to shaft holding power, a vital feature in today's high speed machinery. SEALMASTER'S land ridden ball retainer assures accurate spacing of balls, eliminating ball wear while equally distributing radial and thrust loads. A labyrinth seal consisting of felt-lined steel flingers rotating in labyrinth prevents entry of dust and dirt and retains proper amount of lubricant. SEALMASTER'S patented locking pin and perimeter dimple prevents rotation of outer race assuring positive lubrication while allowing for several degrees of misalignment.

Whether you design air conditioning equipment or road machinery; textile machines or farm equipment you'll want full information on these and other SEALMASTER features.

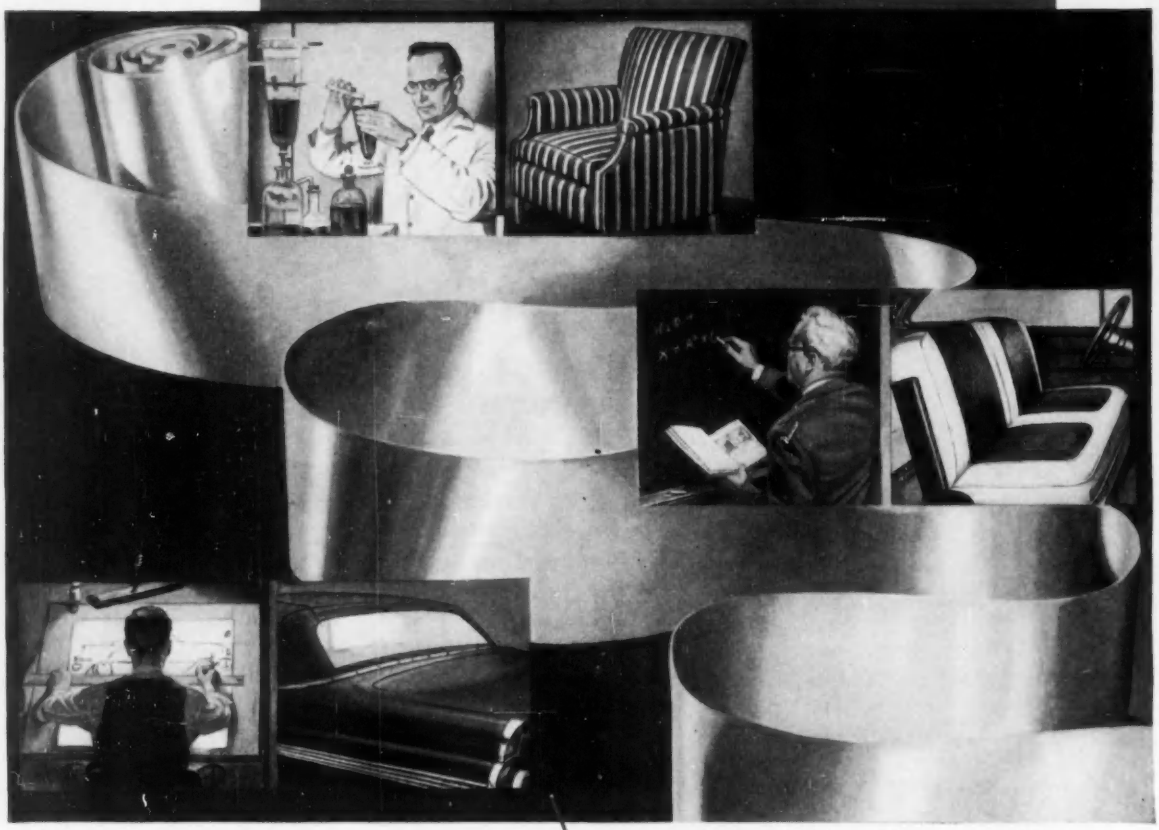
Write for Bulletin 454 for full information

SEALMASTER®

BALL BEARING UNITS

SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO. 9 RIDGEWAY AVENUE, AURORA, ILL

THESE RESINS GIVE YOU NEW ANSWERS TO PRODUCT AND PROCESSING PROBLEMS



New improved Exon 900 series with tailored blending qualities means faster, more versatile production

. . . typical of the pin-pointed properties in Exon Vinyl Resins

Here is another addition to Firestone Exon's growing list of pin-pointed answers to specific problems: the new improved Exon 900 series.

These three new polyvinyl chloride resins offer many profitable advantages. The most important is greater versatility in both production and in the products you can make. For now Firestone gives you tailored blending to answer product and processing problems.

Firestone engineers have improved both the *absorptive* and *adsorptive* qualities of these new PVC resins. As a result, you get a greater pre-mix blending range, whether running hot or neutral. You can blend greater amounts of monomeric or polymeric plasticizer in the formulation. You get a wider area of temperature control.

To these temperature-tailored resins add the advantages of faster solvation, faster fusion rates in Banburys and mills, high quality, less fisheyes, greater product uniformity. New Exon 900 series resins give you greater dollar economies through quicker production.

Exon 911, 921 and 931 are just three of the resins in industry's most complete line of versatile vinyls. Another reason industry looks to Firestone Exon for engineered answers to its needs.

Consider your own production or product problem. Then for the resin properties pin-pointed to the best solution for you, check with Firestone.

Firestone

EXON

RESINS

For complete information and technical service, call or write:

CHEMICAL SALES DIVISION: FIRESTONE PLASTICS COMPANY

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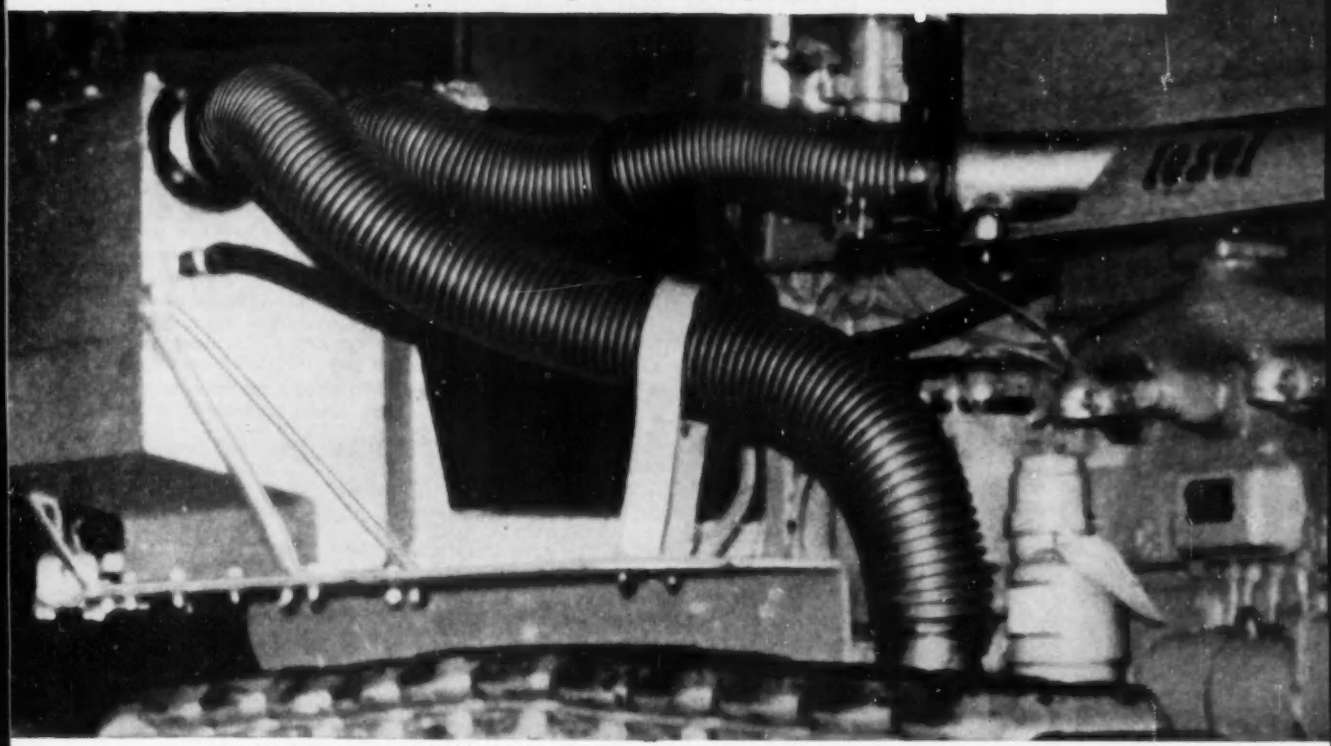
IN CANADA, CONTACT CHEMICAL SALES DIVISION, FIRESTONE TIRE AND RUBBER COMPANY OF CANADA, LTD. HAMILTON, ONT.

INDUSTRY'S MOST COMPLETE LINE OF VINYLS ENGINEERED TO YOUR SPECIFIC NEEDS

Where you convey gases

and have problems of vibration, misalignment, moving parts or cramped spaces



3" and 4" I.D. American Flexible Stainless Steel Hoses used to convey hot exhaust gases on this Caterpillar D2 Diesel Tractor, equipped with Exhaust Conditioner, used in underground, hard-rock mining operations.

Get more service hours per dollar with American Flexible Metal Hose

Famous quality construction of American Flexible Metal Hose offers you the security of trouble-free, leakproof service in conveying gases, whatever your needs. Proof of this is American's enviable record—in thousands of applications—for the pressure-tight conveyance of air, oxygen, hydrogen, nitrogen, acetylene, propane, butane, Freon, ammonia, and many other gases under both high and low pressures.

And—because of its flexibility—American Flexible Metal Hose absorbs vibration and prevents its transmission into surrounding structures . . . travels with expansion and contraction due to temperature changes . . . facilitates installation, particularly in cramped spaces . . . solves problems of misalignment and moving parts.

Available in a wide range of diameters in tough, corrosion-resistant bronze, steel, supernickel, brass, stainless steel or other metals, American Flexible Metal Hose delivers the very highest *service hours per dollar.* You can order complete assemblies with end fittings attached—made to your specifications and ready for immediate installation.

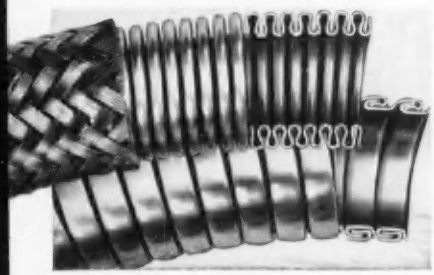
Before your next design job, call your nearby American Metal Hose representatives for engineering help. Their suggestions will help you solve and save on connector problems. The American Brass Co., American Metal Hose Div., Waterbury 20, Conn. In Canada: The Canadian Fairbanks-Morse Co., Ltd.

56179 Rev.

WHEREVER CONNECTORS MUST MOVE

AMERICAN FLEXIBLE METAL HOSE AND TUBING

AN **ANACONDA**® PRODUCT



BASIC TYPES

Seamless corrugated and Strip-wound. Both types available in a wide range of sizes and styles in any workable metal. Furnished with or without end fittings attached.

THE AMERICAN BRASS COMPANY
American Metal Hose Division, Waterbury 20, Conn.

Please send me a free copy of your new flexible metal hose and tubing catalog, G-560.

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New trends and developments for design engineers . . .

How Carboloy® cemented carbides' wear-resistance and other unique properties solved three tricky problems

Carbides' low coefficient of thermal expansion keeps tiny parts tiny

The Van Keuren Co., Watertown, Mass., specializes in precision measuring tools, and tiny parts such as bearings and pivots for instruments, components, and missiles.

Dimensions of these parts are often measured in thousandths . . . and their tolerances in millionths.

It's hard enough to *make* anything as small as the pivot shown in Figure 1, but once it's done, making sure it *stays* that size despite ambient temperatures and rugged operating conditions is another problem.

FIG. 1 — Carbide pivots measure .0030" in diameter, .0165" in length.

Carboloy cemented carbides were the perfect solution because they do not expand and contract like other materials. Their coefficient of thermal expansion is less than half that of SAE 1095 heat-treated steel.

For example, from 70° to 1292°F., Carboloy Grade 779 has a coefficient of 2.80 x 10^{-6}/°F. — compared to 8.20 x 10^{-6}/°F. for SAE 1095.

In addition, carbides resist atmospheric corrosion and erosion. They can be lapped and polished to a mirror finish for smooth, accurate bearing action. And they're ideal materials where compressive loads are high because carbides' ultimate limit in compression is 2 to 16 times that of steel.

Carbides' high temperature resistance solves soldering problem for H. & A. Selmer

Soldering clarinet keys in place takes a steady hand with the gas torch, and special jigs for holding and positioning tiny assemblies (Figure 2).

H. & A. Selmer, Inc., leading manufacturer of band instruments had no trouble getting the steady hands. The problem was with the jigs.

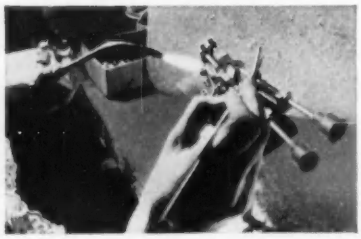


FIG. 2 — Carbide points hold and position clarinet key assembly during soldering.

Because of the high temperatures needed for silver soldering the nickel-silver keys, Selmer was using stainless steel jigs. Unfortunately, the keys often ended up soldered to the jig; as well as to their own parts. This meant hours of hand filing, extra cleaning, frequent repairs of the jigs.

Then Selmer engineers introduced the use of Carboloy cemented carbide location points. In addition to being the hardest metals made by man, they have the ability to resist excessive oxidation at temperatures of 1500° to 1600° F.

And, once carbide is coated with a thin layer of oxide, neither the solder, nor the keys, will stick to the holding and location points.

Soldering operations were speeded up; hand filing eliminated; jigs stayed accurate longer—and Selmer's costs came tumbling down.

Carbide's resistance to corrosion keeps printing ink flowing for IBM

When IBM makes IBM cards, it makes them by the millions. And it makes them on special high-speed machines that automatically print, cut, and count 1600 cards a minute.

Each machine has its own miniature printing press. Ink is metered out by a stainless steel pump submerged in a well in the machine base.

Wear on the pump parts was problem enough. But the ink was also corroding its impeller bushings and shaft.

IBM engineers solved the problem by installing Carboloy cemented carbide bushings and shafts.

Normally, carbides are not used for their corrosion resistance alone.

But, as in cases like this, where a *combination* of corrosion-resistance and wear-resistance is needed, Carboloy cemented carbides can more than pay their own way.

They have good resistance to organic acids, many inorganic acids and bases . . . and are practically inert to attack by salt water spray.

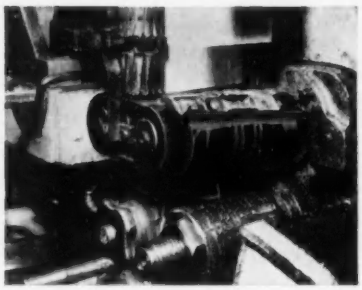


FIG. 3 — Miniature printing press in IBM card machine. Note carbide shearing knives above the printing plate.

Incidentally, IBM is also saving an estimated $40,000 a year in labor costs for regrinding the rotary shear knives used to cut the cards to length.

By changing to Carboloy carbide knives, 267 million cards are trimmed before resharpening — compared to only 16 million with steel knives.

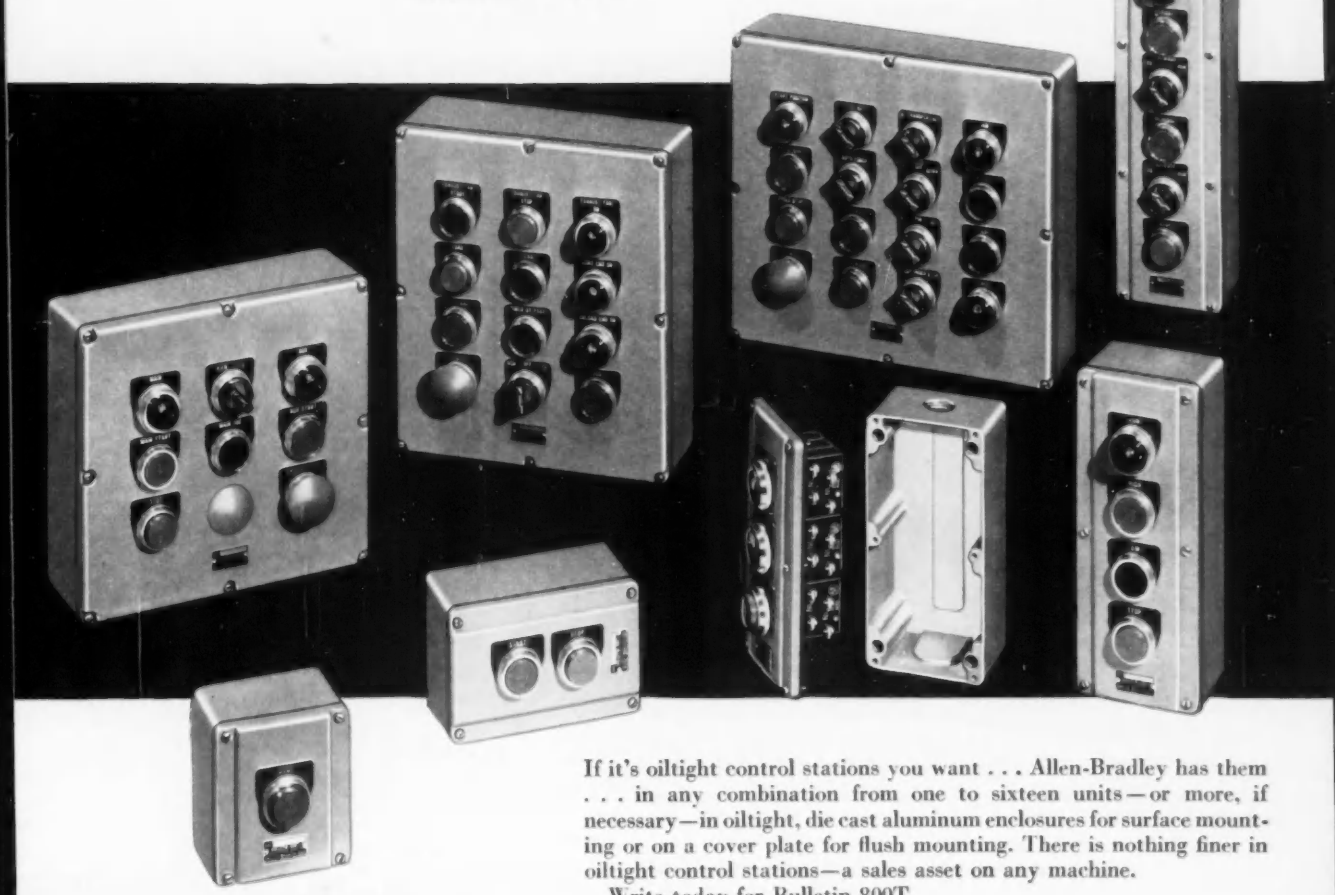
IBM, Selmer, and Van Keuren each used a *different* grade of carbide. Because Carboloy carbides are available in 19 standard grades, they could select the grade with exactly the right characteristics for their particular needs.

If you would like additional technical data on the unique properties of this material—or expert assistance on design problems, write: *Metallurgical Products Department of General Electric Company, 11127 E. 8 Mile Ave., Detroit 32, Michigan.*

CARBOLOY®
CEMENTED CARBIDES
GENERAL ELECTRIC

NOTHING FINER IN oiltight control stations

BULLETIN 800T

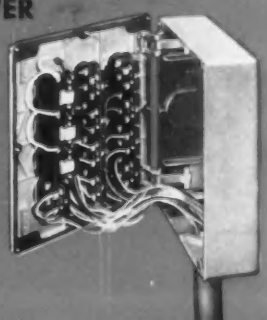


If it's oiltight control stations you want . . . Allen-Bradley has them . . . in any combination from one to sixteen units—or more, if necessary—in oiltight, die cast aluminum enclosures for surface mounting or on a cover plate for flush mounting. There is nothing finer in oiltight control stations—a sales asset on any machine.

Write today for Bulletin 800T.

HINGED COVER

The 9, 12, and 16-unit control stations have hinged covers. The hinge can easily be changed in the field from one side to the other.



ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
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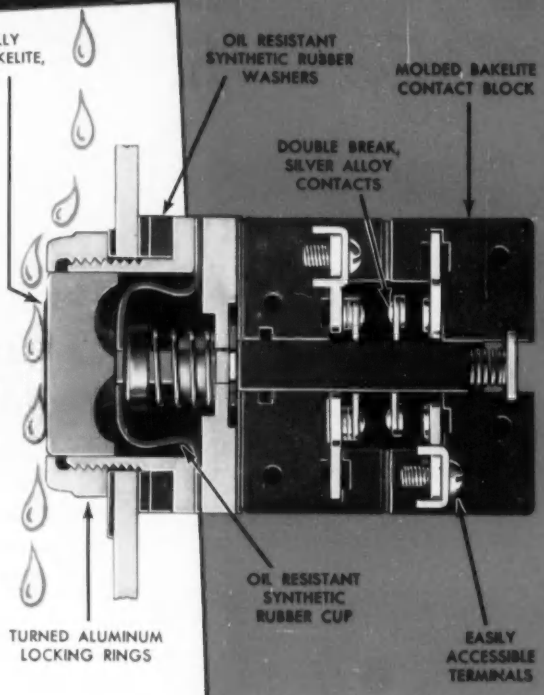
10-57-RM

for machine tool application . . .

BULLETIN 800T oiltight control units

These rugged, reliable units were designed as pilot controls for a-c and d-c magnetic motor control. The oil resistant synthetic rubber cup and washers keep cutting fluids and oil away from the contacts, and thus prevent trouble. Push button units can be furnished with one, two, or four contact blocks—each equivalent to a separate single pole, double throw, switch unit.

For attractive appearance plus long life with reliable operation, select Allen-Bradley control units.

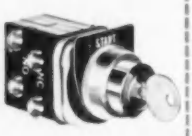

LARGE, FULLY GUARDED, BAKELITE, BUTTON
OIL RESISTANT SYNTHETIC RUBBER WASHERS
MOLDED BAKELITE CONTACT BLOCK
DOUBLE BREAK, SILVER ALLOY CONTACTS
OIL RESISTANT SYNTHETIC RUBBER CUP
TURNED ALUMINUM LOCKING RINGS
EASILY ACCESSIBLE TERMINALS

PUSH BUTTONS

Flush Head Start" Button

Extended Head "Stop" Button

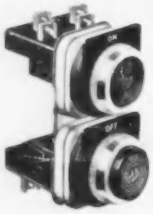
Mushroom Head for Easy Operation



Push Button with Cylinder Lock

Push Button with "Selector" Sleeve

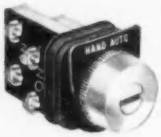
Wing Lever Push Button



Maintained Contact Push Buttons

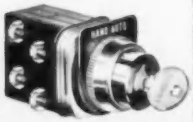
SELECTOR SWITCHES

Three-Position Selector Switch



Two-Position Coin Slot Selector Switch

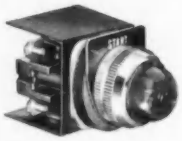
Wing Lever Selector Switch



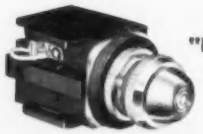
Selector Switch with Cylinder Lock

PILOT LIGHTS

Transformer Type Pilot Light



Full Voltage Pilot Light



"Press-to-Test" Pilot Light

A-B QUALITY

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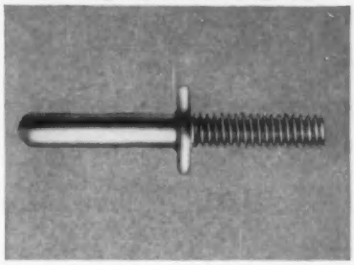
National SPECIAL PRODUCTS SERVICE

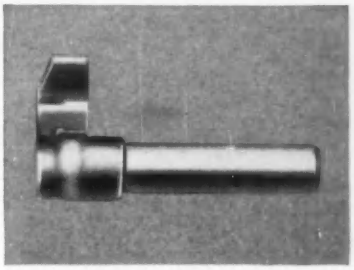
Precision parts with closely held tolerances and excellent surface finish, like this, can also be cold headed more economically and quickly.



Small parts like this can be produced, by cold heading, in huge hourly volume and at low unit cost.

Get strength at low cost with

COLD HEADED SPECIALS!



Intricate formations, like this, difficult or too costly by other methods, become routine production in the cold heading process.

You can make remarkable savings and get better parts in many cases by letting us duplicate and improve on parts you previously have had machined, cast or forged. It's possible with National cold heading!

What's more, we can quickly tell you whether cold heading would be an advantage for new designs.

Here's how National cold heading reduces unit costs . . . gives you better parts!

You save on production costs, because cold heading is fast . . . production rates of 50 to 300 pieces per minute are common. You don't pay for waste. Scrap loss in cold heading is negligible. You save on cost of extra operations, because cold heading eliminates them entirely or reduces their number. And most secondary operations, when required, can be performed automatically in mass production.

Cold heading assures strong, sound parts with good finish and excellent resistance to fatigue, shear and impact!

You're sure of strong parts because cold working *increases* the strength of steels and nonferrous metals. Subsequent heat-treatment or hardening can produce practically any degree of physical properties you desire.

You're sure of sound, clean parts because any defects, such as seams and inclusions, will open up in cold working . . . resulting in *automatic rejection.*

You're sure of superior fatigue, shear and impact resistance because cold heading produces continuous, unbroken flow lines in the grain of the metal . . . impossible to obtain by any other method.

You're sure of good surface finish, with a maximum of 50 micro-inch on cold headed surfaces. Cold heading won't cut or break the specially prepared, smooth, compressed and toughened surface of the rod.

National's cold heading specialists have many years of design and production experience. Combined with National's tremendous facilities for cold heading and secondary operations, this assures you of outstanding work and help in design and production of your parts.

Write for National's booklet, *Special Products.* To learn more about what National cold heading can do for you, send us your specifications or call in your nearest National representative.

THE NATIONAL SCREW & MFG. CO. • CLEVELAND 4, OHIO

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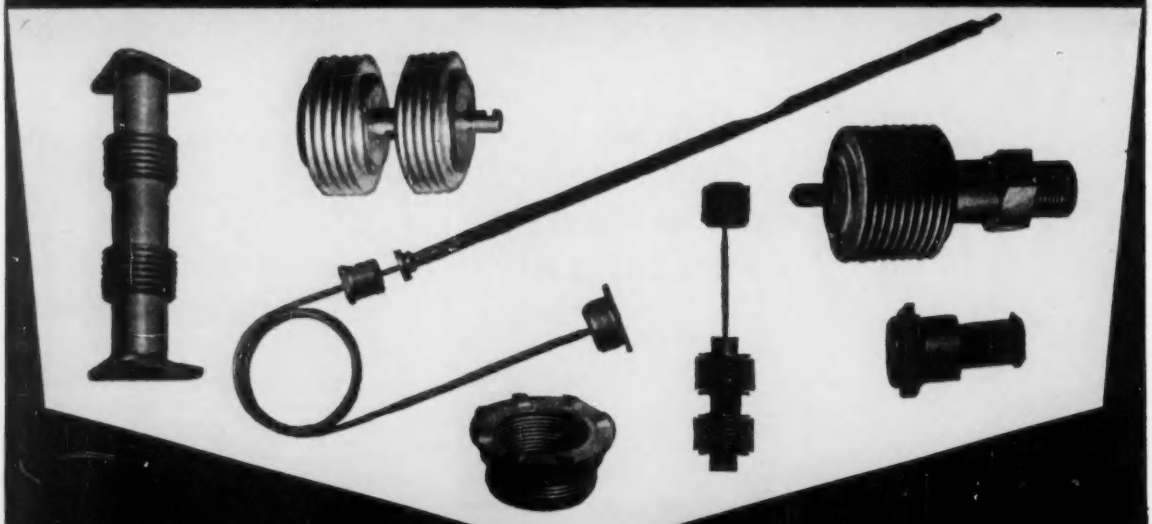
National PRODUCTS

Fasteners **Hodell Chains** **Chester Hoists**

HOW TO SAVE TIME AND MONEY ON COMPLETE BELLOWS ASSEMBLIES



No matter why or how the bellows principle enters into an assembly, Fulton Sylphon can assemble the right bellows and related accessories or mountings into a complete device that meets your specifications. In doing this Fulton Sylphon offers important design help, specialized skill in joining bellows with other members, and modern production facilities for on-time deliveries.

BELLOWS FOR INSTRUMENT ASSEMBLIES

are available with diameters, lengths, strokes, spring rates, metals and charges to provide a wide range of movements in high or low pressure systems. In all applications the exclusive Sylphon® bellows assures continuing accuracy and safety of operation. For one thing, cold-working production methods give it maximum resiliency for withstanding repeated cycling. In addition, its *seamless* design and the availability of multiple plies enable the Sylphon bellows to better resist pressure and other conditions.

Send for Bellows Catalog 1400TP

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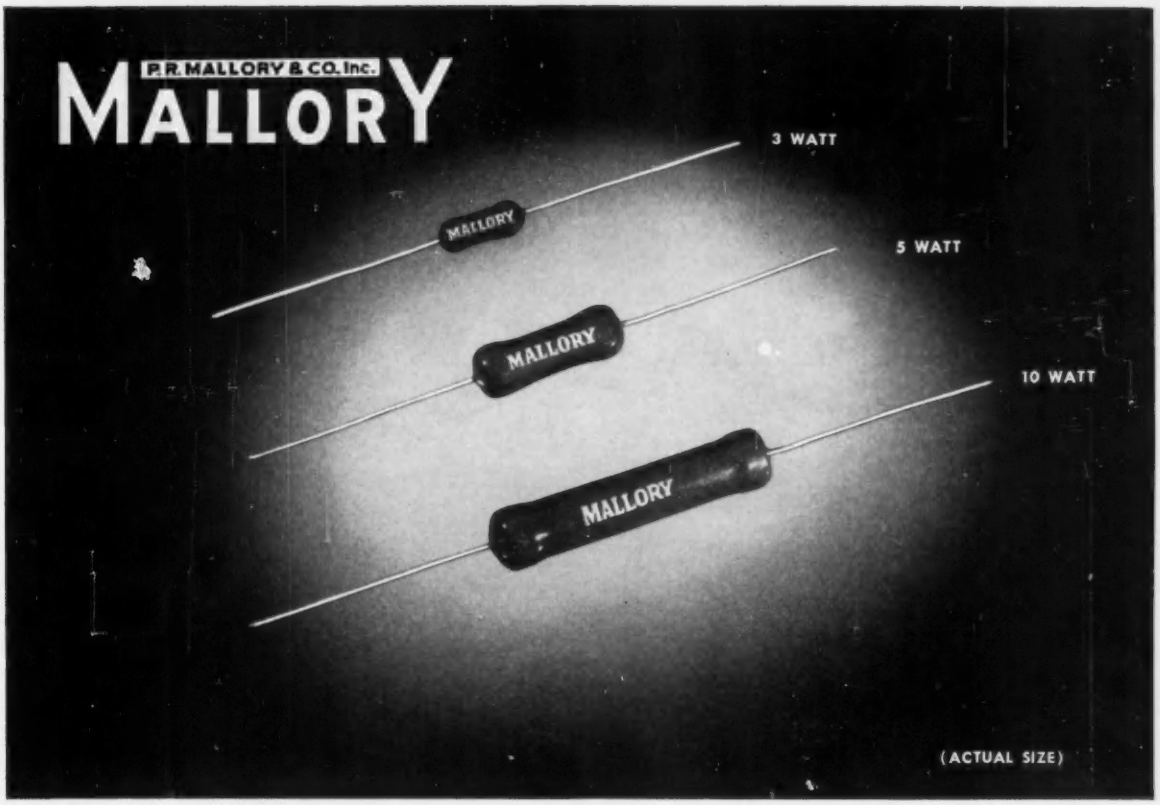
FULTON SYLPHON BELLOWS HEADQUARTERS, U.S.A.



New Axial Lead Vitreous Resistors enable compact, point-to-point wiring

Mallory's new AE line of vitreous enamel power resistors were developed to aid designers in miniaturizing equipment. They can be mounted without hardware and wired point-to-point because of exceptionally small physical size for their ratings. The end caps, specially welded to the resistance element by an exclusive Mallory process, won't come loose from vibration or soldering-iron heat.

Mallory AE resistors are being made in accordance with the MIL-R-26C specifications in styles RW-57, RW-58, and RW-59. They are built of thermally matched materials, providing an exceptionally high resistance to thermal shock. Typical rugged Mallory construction throughout provides a high degree of resistance to mechanical shock and humidity.

The new AE resistor line includes types 3-AE, 5-AE and 10-AE—having 3-, 5-, and 10-watts ratings, respectively. RETMA standard resistance values are available in all three power ratings. Write—or ask the Mallory representative for complete information on the new AE line of vitreous enamel, axial lead power resistors.

Expect more... get more from

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Serving Industry with These Products:

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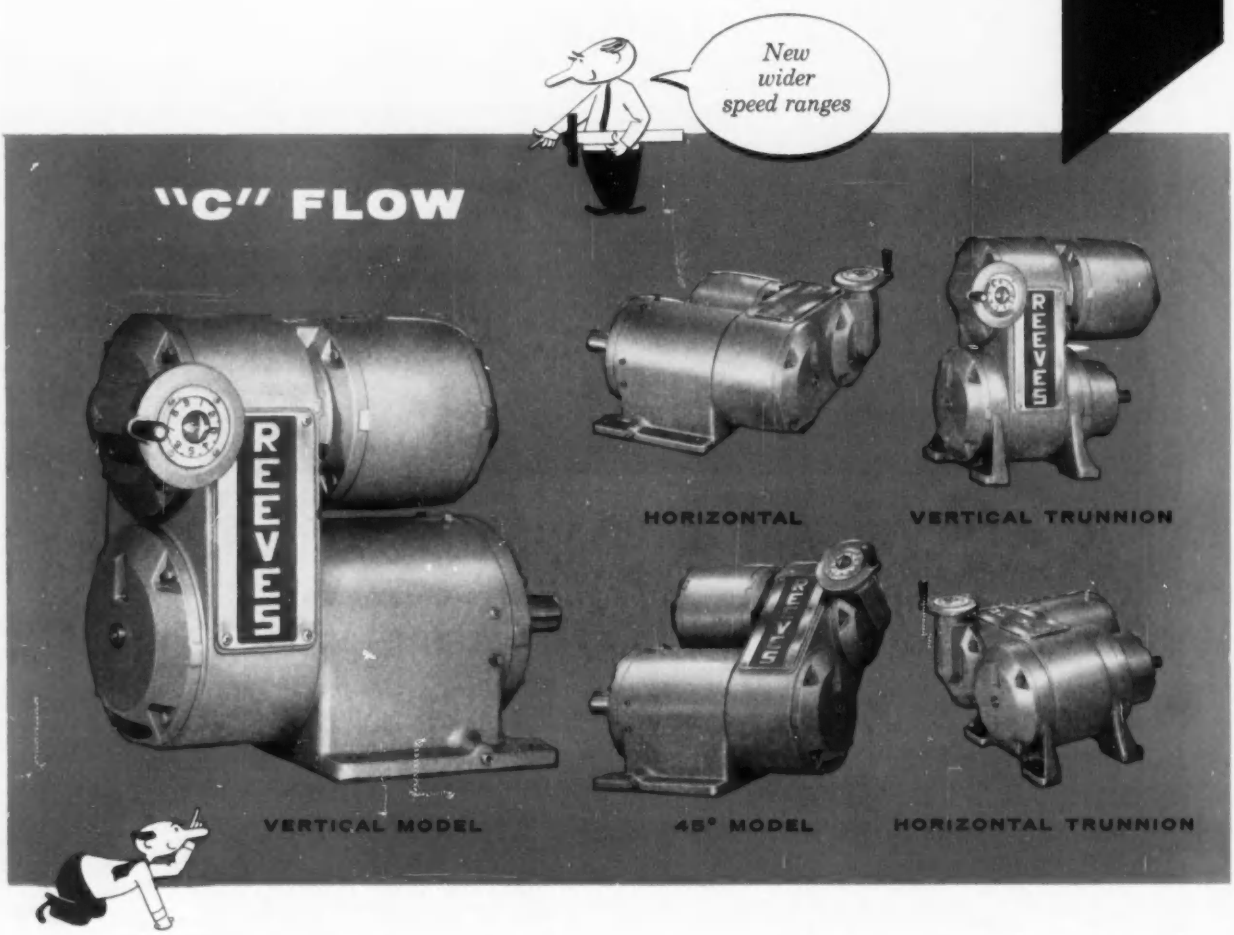
variable speed with new versatility and performance



A triumph of new Motodrive design . . . inside and out

New REEVES Vari-Speed Motodrives, sizes 200 and 300, are complete variable speed power packages, built with compactness and precision, to give improved performance on installations 1 through 5 hp.

The new sizes are designed in two styles—"C" flow and "Z" flow. In each style, there are several different models and reducers with increased capacity in single, double or triple stages.

The flexible design permits hundreds of combinations . . . space-saving, space-fitting *standard* assemblies to meet most installation requirements.

The handwheel control location can be rotated to optional positions for greater operating convenience; extra precision of control is available with the addition of one or more REEVES accessories or modifications.

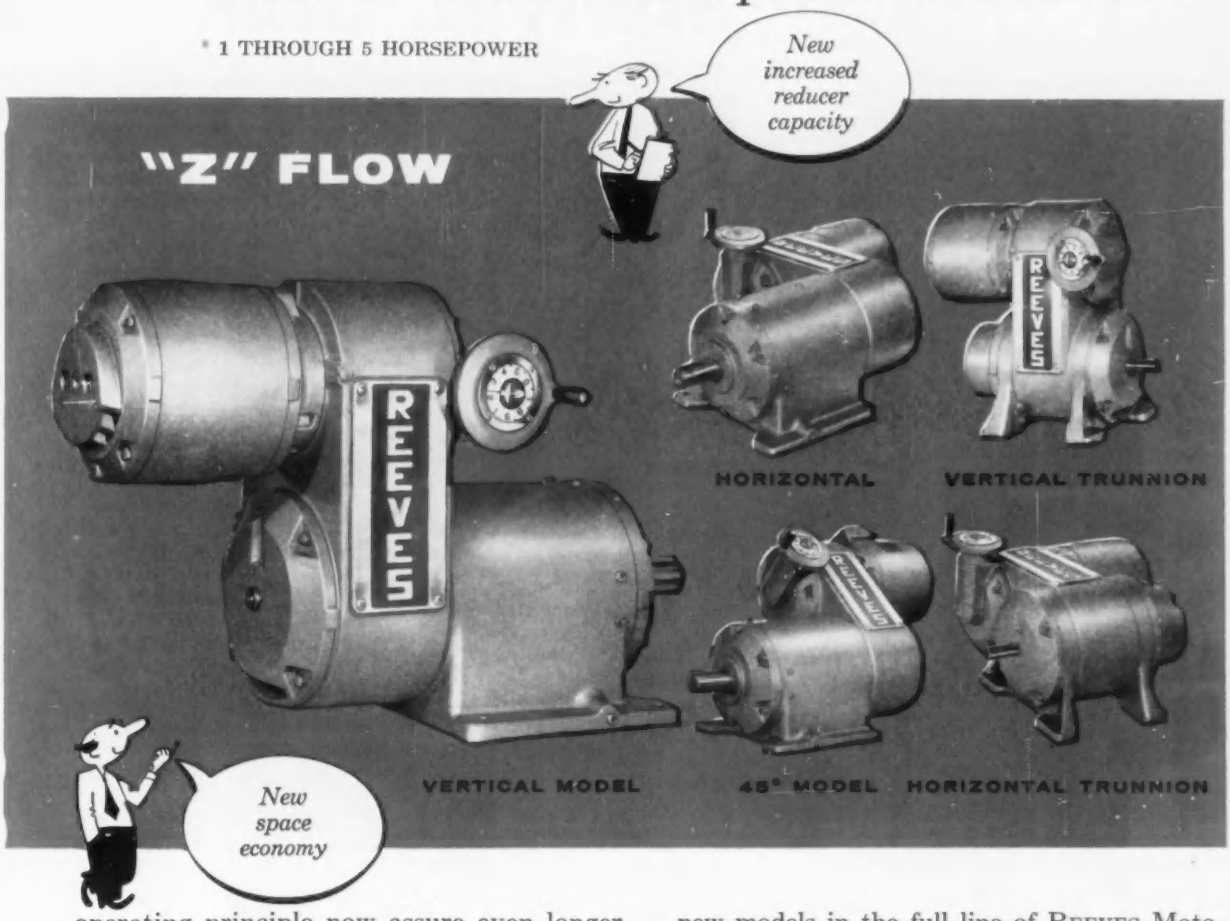
Refinements to the time-tested REEVES

NEW

REEVES®

*Sizes 200-300 Vari-Speed MOTODRIVES**

* 1 THROUGH 5 HORSEPOWER



operating principle now assure even longer trouble-free service.

New disc assemblies permit wider output speed ranges . . . discs are pre-aligned . . . pre-loaded spring maintains correct belt tension for longer belt wear . . . *exclusive* "close-grooving" lubrication assures free sliding discs . . . new Metermatic system automatically lubricates the motor and variable shaft bearings.

Sizes 200 and 300 are versatile, hard-working new models in the full line of REEVES Motodrives which provide instant and accurate variable speed control on ¼ through 40 hp. applications.

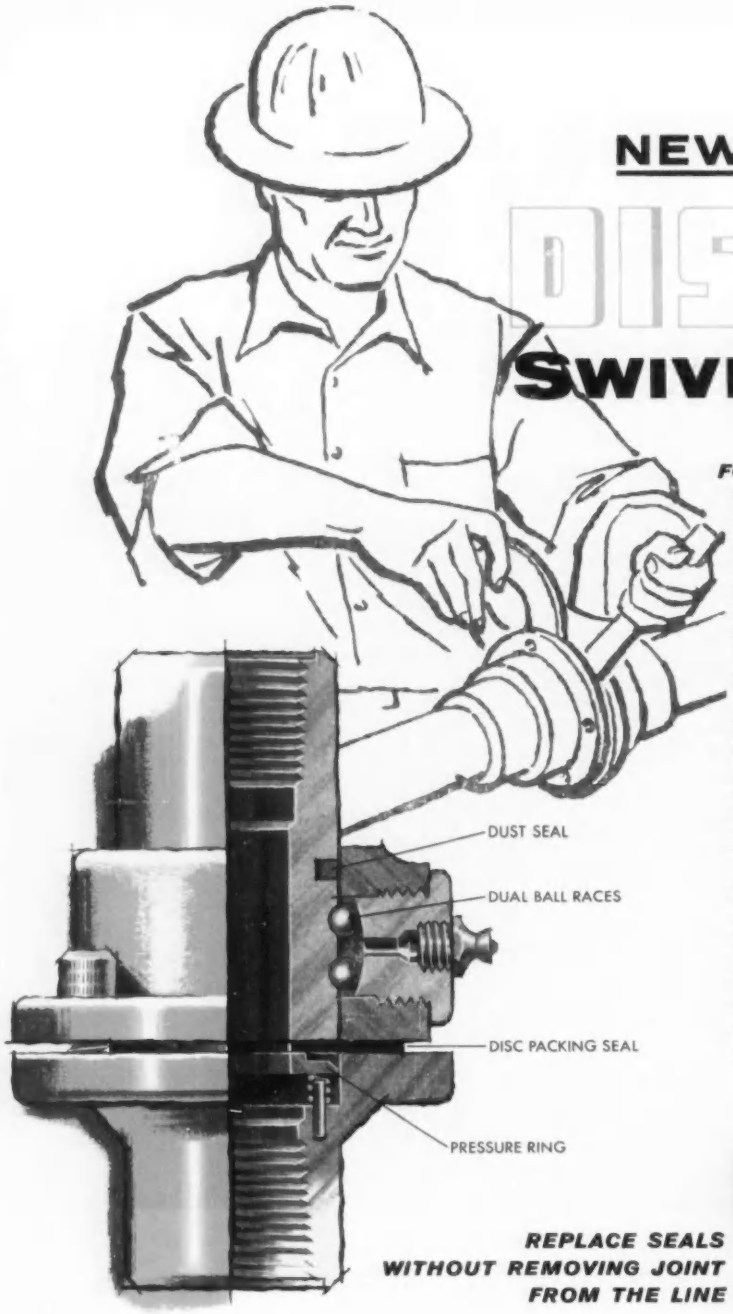
Complete details, dimensions, illustrations and prices on assemblies, modifications and accessories are in Catalog K31b-M571. Write for your free copy today.

REEVES PULLEY COMPANY

Division of **RELIANCE** ELECTRIC AND ENGINEERING CO.

Columbus, Indiana

NEW CHIKSAN DISCPAK SWIVEL JOINTS

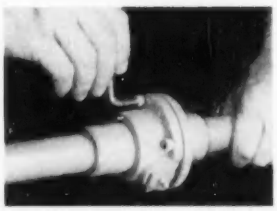


FOR STEAM AND HOT GAS SERVICE

Created specifically for service on lines employed in steam and hot gas service, the Chiksan Discpak embodies a new construction design which permits packing units to be replaced without removing the joint from the line. The outer housing of the Discpak is cut apart at the packing chamber and both ends are flanged at the cut. Four allen-type cap screw bolts are used to secure the flanges. A disc-seal, housed between the two members, provides a fluid-tight seal between rotating and stationary members of the Discpak Swivel Joint. A spring loaded pressure plate holds the packing in sealing position against the swiveling member.

The new Discpak has a maximum temperature rating of 600° F. and a maximum pressure rating of 300 psi. All turning movement in the Discpak takes place on a double row of precision ball bearings. Write today for literature and prices. If your plant or equipment lines utilize hot gas or steam, it will pay you to know about this new field-proven Discpak swivel joint.

REPLACE SEALS WITHOUT REMOVING JOINT FROM THE LINE



To replace the disc-seal, simply remove four allen screws and spread line slightly with a flat metal bar.

CHIKSAN

CHIKSAN COMPANY, 330 No. Pomona Avenue, Brea, California

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Please rush me a copy of your new Discpak Bulletin

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SEND FOR BULLETIN

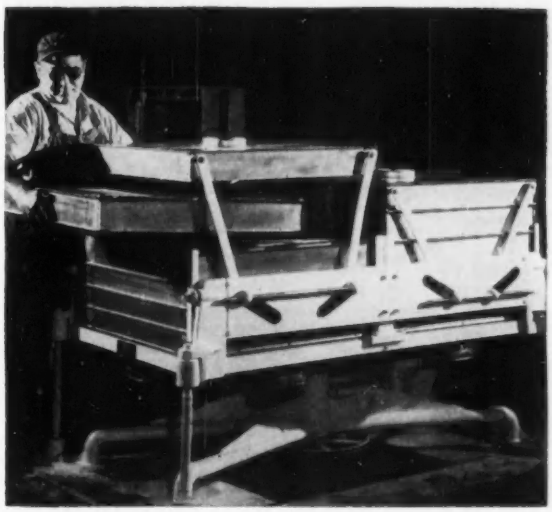
New Discpak Bulletin 100 describes in detail the many features of this new swivel joint including full mechanical specifications.

57-26

NOTHING can equal Stainless Steel

in its unique combination of properties

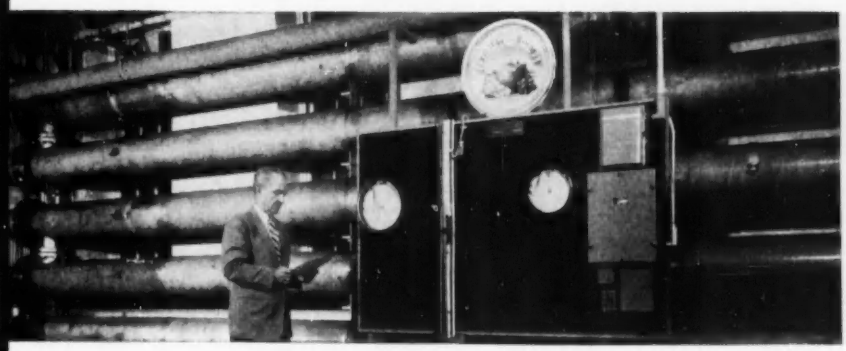
No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. For a reliable source of supply, United States Steel offers you the widest range of types, finishes and sizes. **Just call your steel warehouse.**



For Humid Locations. The Richmond Sifter is made by Sprout-Waldron in Muncy, Pa. Unit shown here has two sets of full-size sieves, containing up to 90 square feet of bolting area. Up to six separations can be made from each of the two sections, and two different materials can be spouted to the sifter. Stainless Steel sieves are supplied when humidity or temperature is high—or when corrosive materials must be sifted. Many sifting applications could not be economically handled without the Stainless Steel sieves.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

For Permanent Beauty. The Santa Fe made news last year when they announced the revolutionary "El Capitan" train. Cars are 15½ feet high, two feet higher than standard, and they are completely sheathed with beautiful Stainless Steel. And in addition to being a glamour metal, Stainless has the corrosion resistance to assure years of gleaming beauty. One Stainless Steel train has been in service over 20 years, and the exterior is still in perfect condition.



For Operating Economy. A textile manufacturer found that they could save about $70,000 yearly by using waste hot water to pre-heat the incoming fresh process water. Problem: the hot water had a heavy caustic soda content. Solution was a super-efficiency unit purchased from Ludell Manufacturing Company, in Milwaukee. It is made completely from Type 304 Stainless Steel and contains 19,000 lineal feet of tubing inside the shell units. It is doubtful that any other material could have been used under these conditions. Even better, the unit is expected to last indefinitely.

USS STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

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(Advertisement)

SPECIAL REPORTS ON FINISHING NON-FERROUS METALS

NUMBER III—Lustrous, Corrosion-Resistant Finishing with Chemical Polishing Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are widely accepted throughout industry as an economical means of providing corrosion protection, a good base for paint and decorative finishes for non-ferrous metals. Certain of these coatings also possess chemical polishing abilities that have luster-producing, as well as corrosion-inhibiting, effects on zinc and cadmium plate, zinc die castings and copper alloys. However, continued developments in this field have been so rapid that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this discussion of the many ways in which this chemical polishing characteristic can be used in final finishing or pre-plating treatments to produce a lustrous appearance with distinct display and sales appeal and appreciable savings in cost. Report I on decorative, corrosion-resistant finishes and Report II on paint base corrosion-resistant finishes are available on request.

The degree of luster possible on a surface is a function of the degree to which the surface can be smoothed. Leveling to provide a smooth surface can be achieved by mechanical or chemical means, or a combination of these, depending upon the luster desired and the original condition of the metal. Chemical polishing effectively imparts luster otherwise difficult and costly to obtain. For this reason, it is often used to supplement or entirely replace mechanical polishing, depending upon the application and the original condition of the metal. Chemical polishing has the additional advantage of providing overall treatment of the submerged part. It reaches into even the deepest corners and recesses that are otherwise inaccessible. Certain of the Iridites are specifically designed to perform this chemical polishing operation. Also, they provide corrosion protection as do all Iridites, thus may be used as a final finish or a pre-plating polish.

If Iridite is to be used as a final finish, in contrast to pre-plating treatment, the chromate conversion coating generated is allowed to remain, providing good corrosion resistance. Color inherent in these Iridite films ranges from a yellow cast to yellow iridescent. These coatings may be used without further treatment where this color is acceptable and good corrosion resistance is desired. Further, these basic coatings can be tinted by dyeing. Among the dye tints available are shades of red, yellow, blue and green. If desirable, the basic coatings can also be modified by a bleach dip leaving a clear bright or blue iridescent finish. In all cases bleaching reduces corrosion resistance.

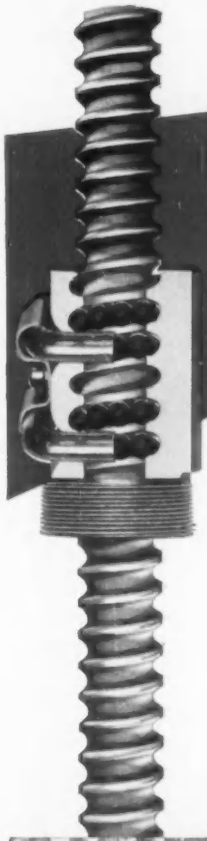
As examples of this type of final finishing, Iridites #4-73 and #4-75 (Cast-Zinc-Brite) make possible for the first time, lustrous chemical polishing of the as-cast surface of zinc die castings. Thus, in many cases, sizeable savings in finishing cost are realized by elimination of plating costs. This economical method can be used on tools, appliance parts, toy pistols, locks and many other small castings. Another example is the treatment of copper and brass parts, such as welding tips, to eliminate buffing and provide additional corrosion resistance. In many cases, handling costs are reduced appreciably by replacing piece-part handling with bulk processing. Still another example of the use of this chemical polishing and protective quality of Iridite is a simple system of zinc plate, Iridite and clear lacquer instead of more costly electroplated finishes. Typical of this type of lustrous finish are builders hardware and wire goods.

As a pre-plating treatment, in contrast to final finishes, Iridite can be used to chemically polish zinc die castings or copper prior to plating. In such cases, Iridite should be applied as an in-process step, so that the protective film is removed before the plating cycle. The savings in handling, material and labor costs are obvious. This process has made it practical to plate chrome directly over copper on steel, conserving nickel, yet producing a lustrous chrome finish. Used after stripping faulty plate in reprocessing zinc die castings, Iridite restores luster to the casting, thus making possible replating without blistering.

Other Iridite finishes are available to produce maximum corrosion resistance, a wide variety of decorative finishes and excellent bases for paint on all commercial forms of the more commonly used non-ferrous metals. As a final finish, appearance ranges from clear bright to olive drab and brown and many films can be bleached or dyed. As a paint base Iridite provides excellent initial and retentive paint adhesion and a self-healing property which protects bare metal if exposed by scratching. Iridites have low electrical resistance. Some can be soldered and welded. The Iridite film itself does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of their top performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product demands the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.

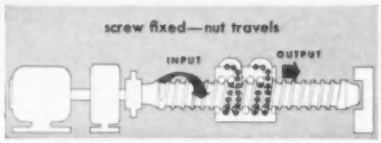


FOR MORE EFFICIENT PRODUCTION—

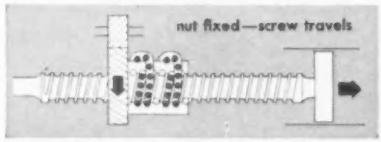
ACTUATE OR POSITION IT BETTER WITH

SAGINAW b/b SCREWS

6 decisive advantages reduce manufacturing problems and costs:



FORWARD: When rotary motion is applied to the screw, the b/b nut is driven along the axis of the screw, changing rotary motion to linear motion.



FORWARD: When rotary motion is applied to the b/b nut, the screw is driven along its longitudinal axis, changing rotary motion to linear motion.

1 **POWER SAVINGS.** Operating with over 90% efficiency, Saginaw b/b Screws permit much smaller motors with far less drain on electrical systems, and also simplify circuitry.

2 **SPACE SAVINGS.** Saginaw b/b Screws themselves are compact. They permit smaller motors and gear boxes and eliminate auxiliary equipment required by hydraulics.

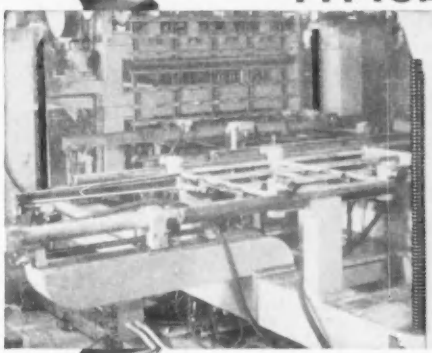
3 **DEPENDABLE PERFORMANCE.** Saginaw b/b Screws are far more reliable than hydraulics or pneumatics. Gothic-arch grooves, yoke deflectors and multiple circuits provide added assurance.

4 **PRECISE POSITIONING.** Saginaw b/b Screws will position components far more precisely than hydraulics or pneumatics; tolerances on position are held within .0006 in./ft. of travel.

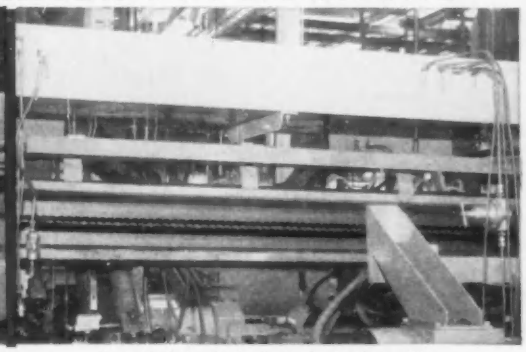
5 **TEMPERATURE TOLERANCE.** Normal operating temperature for Saginaw b/b Screws is from −75°F. to +275°F. But in selected materials, they will function efficiently at temperatures as high as +900°F.

6 **LUBRICATION.** If lubrication fails the Saginaw b/b Screw will still function with remarkable efficiency. Units have been built and qualified for operation without lubrication.

TYPICAL AUTOMATION APPLICATIONS



Automatic indexing device for stacking material. Saginaw b/b Screw used to raise and lower table.



Automatic device for loading and unloading machine. Saginaw b/b Screw used to save power and space.

If you would like further details on the use of Saginaw b/b Screws to increase the efficiency of plant operations, or specific application recommendations for your individual processes, experienced Saginaw engineers are at your service without obligation. Just write or phone us your requirements, or fill in and mail the handy coupon below.

Saginaw

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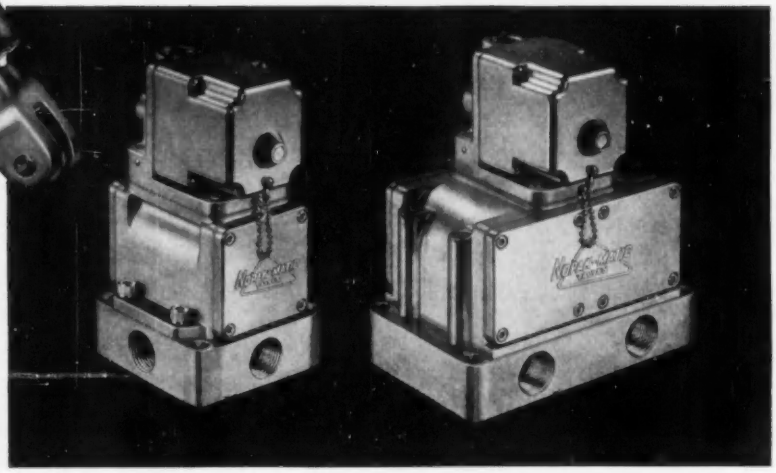
New NOPAK *Team*

delivers PLUS VALUES in Air Power!

NOPAK Air Cylinders, long known for their dependability and economy, now can be applied to even greater advantage with the new Nopak-matic pilot operated air control valves. Full flow design and dependable performance make NOPAK Cylinders and Nopak-matic control valves the perfect "team" for "in plant" or O.E.M. applications. They deliver Plus Values that you can measure in terms of greater speed, higher efficiency, easier maintenance, a wider range of adaptability and versatility.

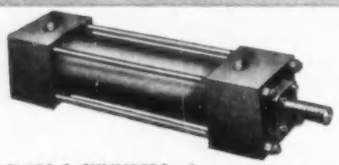


• NOPAK Class 1 and 2 Cylinders are available in 7 standard mountings in bore sizes from 1½" to 14" with a choice of non-cushioned, self-regulating or adjustable cushioned heads on all models.

• Nopak-matic, Pilot-operated, Poppet-type Air Control Valves are available in ¼", ⅜", ½" and ¾" pipe sizes for 2- or 3-Way normally open or normally closed operation, and 4-Way operation with master (air), single or double solenoid control heads. All 4-Way valves available, as standard, with choice of side or bottom ported sub-plates. Air pressures to 150 p.s.i.

Catalog 101-A and Catalog 105 provide complete descriptive and engineering data.

Other NOPAK Products for your Fluid Power Needs



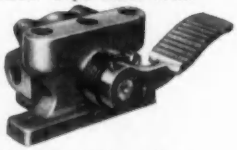
• **CLASS 3 CYLINDERS**—for pressures to 2000 p.s.i. Compact steel plate square head and tie-rod construction. Honed steel tubing. Heads may be cushioned or non-cushioned. Available in 14 standard mounting styles.

• **CLASS 4 CYLINDERS** — High Pressure Hydraulic — Heavy, honed steel tubing with lock-ring flange construction. For hydraulic (oil) service at line pressures to 3000 p.s.i. Choice of cushioned or non-cushioned heads. Available in 5 standard mounting styles.

• **CLASS M CYLINDERS** (Mill Type) Welded flange construction, with honed steel tubing, eliminates tie-rods. Recommended for all types of Heavy Duty air or hydraulic pressures up to 650 p.s.i. depending upon diameter.

The NOPAK line includes cylinders and valves for a wide range of fluid power application — and its precision control. In addition to standard air cylinders, there are heavy duty, mill-type cylinders, square head and lock-ring flange type hydraulic cylinders. The NOPAK Valve line includes the famous packless rotating disc valves in both hand and foot models, high pressure hydraulic valves, Flotrol speed control valves and reciprocating valves.

NOPAK 2- 3- AND 4-WAY HAND VALVES are used to control single or double-acting cylinders at air or hydraulic line pressures to 250 p.s.i. Precision lapped seal eliminates packing, prolongs valve life. Disc rotating at right angle to stream flow permits throttling action or immediate opening to full pipe area. Pipe sizes from ¼" to 2".



NOPAK 2- 3- AND 4-WAY FOOT VALVES incorporate all of the features of NOPAK hand operated disc-type valves including the lapped-disc design and packless construction. They are available in 3 types which are adaptable to a wide variety of control needs. Pipe sizes from ¼" to 1" for pressures to 125 p.s.i.

NOPAK FLOTROL SPEED CONTROL VALVES provide uniform control of cylinder speed in one direction, free flow in the other. Features: quick, easy, precision adjustment without tools; greater capacity; easy installation because of compact in-line design; fit in tight places; made of rust and corrosion proof materials. Pipe sizes from ¼" to 1".

Write for Catalog SW-3

NOPAK VALVES and CYLINDERS

GALLAND-HENNING NOPAK DIVISION • 2762 South 31st St. • Milwaukee 46, Wi.

A7-618-1P

Design data on adhesives

Armstrong

NUMBER FOUR

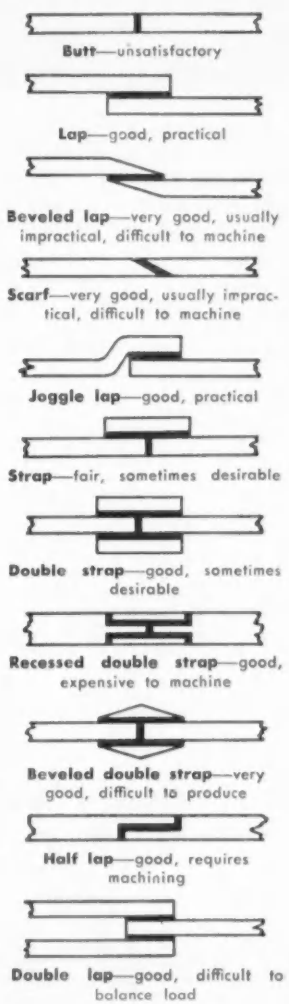
ADHESIVES • COATINGS • SEALERS

How to strengthen metal-to-metal joints for flat plates

In order to strengthen any joint to be adhesive-bonded, four basic rules must be kept in mind. These rules are:

1. Make the bonded area as large as possible.
2. Make the maximum proportion of bonded area contribute to strength.
3. Stress the adhesive in the direction of its maximum strength.
4. Minimize stress in the direction in which adhesive is weakest.

Shown below is a variety of flat plate, metal-to-metal joints to which these rules have been applied.


Butt—unsatisfactory
Lap—good, practical
Beveled lap—very good, usually impractical, difficult to machine
Scarf—very good, usually impractical, difficult to machine
Joggle lap—good, practical
Strap—fair, sometimes desirable
Double strap—good, sometimes desirable
Recessed double strap—good, expensive to machine
Beveled double strap—very good, difficult to produce
Half lap—good, requires machining
Double lap—good, difficult to balance load

Adhesive bonding: application of pressure

Effective adhesive bonding always requires some pressure. This pressure may be applied to an assembly in any one of several ways, depending on the nature of the adhesive, design of the part, and its size. Hydraulic presses, hydraulic pads, hydraulic cylinders, air cylinders, spring-loaded jigs, air-filled rubber bags and vacuum bags have all been used satisfactorily.

Whatever the method, though, it must meet these three basic requirements: (1) the amount of pressure should be adequate; (2) pressure should be retained at a constant level; and (3) it should be distributed uniformly over the work.

How much pressure?

The amount of pressure required varies with the kind of adhesive and assembly. Some thermosetting adhesives, for example, require relatively high pressure (as high as 200 psi) for times ranging from 15 minutes to several hours. On the other hand, certain thermosetting epoxy-resin adhesives will form a tight bond at room temperatures with only enough pressure to maintain contact. Contact adhesives require high pressures, but only for brief periods. If in doubt about the amount of pressure, check the adhesive manufacturer's recommendations.

KRAFT PAPER HONEYCOMB CORE is being bonded to sheet aluminum. Panel moves between rubber-covered pinch rolls which deliver uniform pressure. This momentary application of pressure is all that's required for some thermoplastic adhesives.

Note: in some sheet metal assemblies, some pressure may be required to straighten warped sheets and bring them into full contact. This pressure should be added to the bonding pressure recommended by the adhesive manufacturer.

For a pressure device to be satisfactory, it must retain pressure at a reasonably constant level during the curing period, because changes take place during curing which can effectively reduce the applied pressure. Most adhesives flow under pressure. As a result, the over-all thickness of the joint may be reduced and the pressure lowered. Pressure must "follow up" such reduction in thickness. Pressure devices which may hold very tightly at room temperatures may loosen and reduce pressure on the joint at elevated temperatures, due to thermal expansion of the parts. Again, some follow-up is required.

Screw-actuated assemblies like clamps and bolted jigs are not satisfactory when used alone. But if used in conjunction with springs, air-filled rubber pads or any other arrangement that will provide follow-up, screw-type devices will give good results.

Uniform distribution

Uniform distribution of pressure is most important. High and low pressure spots within an assembly can result in lack of uniform contact and differing film thickness—which may result in variability of bond strength. With rigid fixtures or dies, a "pressure pad" like chipboard, rubber-fabric compounds, or glass cloth may have to be interposed between the face of the fixture and the work to equalize pressure. Assemblies bonded in vacuum bags or autoclaves, with the pressure applied directly to the bond and not through fixtures, have excellent pressure distribution.

If you have a design problem involving adhesive bonding, we may be able to suggest a practical, economical solution based on our 36 years of experience in making and using adhesives, coatings, and sealers. Send details of your problem to Armstrong Cork Company, Industrial Div., 8010 Irvin St., Lancaster, Pa.

R B&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

Fastener coatings

Salt spray testing of various metallic coatings used on fasteners doesn't always give a true picture. In actual service, accelerated test results are not always borne out.

Reason: The tests favor the coatings which can endure continuous moisture and salt atmospheres, whereas some do better under the normal intermittent dry and wet conditions of weathering.

Experience has developed a "scale" of suitability of various coatings for fastener protection.

FOR RUST PROTECTION

Hot galvanizing offers greatest endurance under most conditions. It falls short on highly stressed fasteners.

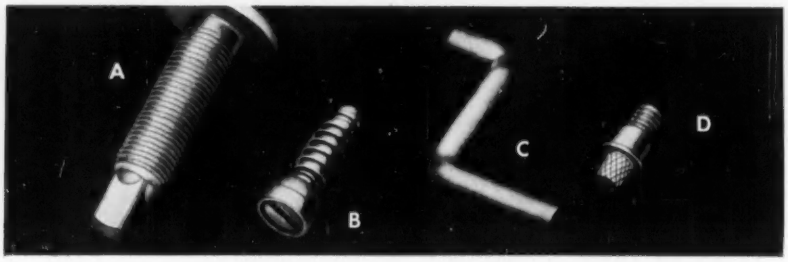
Electrodeposited zinc is next most practical – providing good appearance, controlled tolerance at threads, and ability to take high bolt tensions.

Cadmium plate stands out where salt atmospheres predominate. Not suitable for contact with edibles, it is ruled out for many appliances.

For general applications, the rust prevention of black oxide coatings proves satisfactory. Phosphate coatings, too, offer some degree of protection, but not under severe conditions.

Chromium, plated over copper, should be considered more for its appearance on fasteners rather than protection.

Cold heading creates quality parts the low cost way



No value analysis of product components is really complete without exploring what cold heading machines can do to cut costs. Some examples:

A. ELIMINATE EXTRA OPERATIONS. Leveling screw, formerly made by riveting flat disc to set screw, now emerges as a stronger, single piece from a cold header.

B. ONE PIECE BETTER THAN TWO. Cold headed hose clamp screw has integral flange which, after head is slotted, is forced up to form screwdriver shield. Before, piece was in two parts . . . with screw made on screw machine, and the shield a stamping fitted around head during assembly.

C. FASTER THAN FORGING. Shifter lever is bent into double "L" automatically in bolt header . . . replacing 2-stage forging operation. The header does it at high speed from continuous rod.

D. METAL *FLOWS* TO SHAPE – NO WASTE. No longer cut on screw machine, insert screw for plastic parts costs 40% less. Cold header uses just the amount of metal required. The threading and knurling, too, are done automatically at high speed.

Metal forced to cold flow into shape results not only in savings but also in stronger parts. With uncut flow lines, the piece is better able to withstand stress concentrations.

For an expert opinion on parts you now use, check with Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

12-point fasteners cut wrench clearance space

Double hex RB&W bolts and nuts measure smaller across their points than single hex fasteners. Used with an *external* socket wrench, they permit optimum driving torque to be applied.

Thus, while permitting design of more compact assemblies, these fasteners also assure proper preloading for stronger connections.

Available with plain flange, or SPIN-LOCK design which incorporates teeth that embed upon tightening and resist loosening under vibration or temperature changes.

PERSPECTIVES

in design and development . . .

Universities Hit by Government Research Cuts

The Defense Department, and in particular the Air Force, has made a "tragic blunder" that will damage the military safety and industrial well-being of the United States. The consequences will become apparent within a few years. These are strong statements, but typical of the ones that university administrators are making as they ponder the meaning of Defense contract cancellations that threaten continuation of many basic research projects.

The immediate cause of the current cutback crisis may be eliminated at any time. But regardless of when, research administrators feel serious damage has been done. Crises of this type have occurred before and may occur again. The issues will undoubtedly be essentially the same. It may be well therefore to look at these issues in the light of the present crisis.

Research administrators have been receiving orders since late last summer to stop work on some projects or to cut expenses on others by 5%, and to hold off on payments until next year. The orders have come with dramatic suddenness and with great confusion. In many instances, communications with the government have had a comic-opera flavor. As one administrator put it: "First we get a telegram to cancel a contract, then the next day we get a telegram to cancel the cancellation."

These actions are, of course, in line with the general policy of rigorous economy which has been forced upon the Services by higher administrative authority. A sudden shift from spending freely for research and procurement to a policy of holding spending within narrowly prescribed limits has caused considerable and well-publicized hardship to industry.

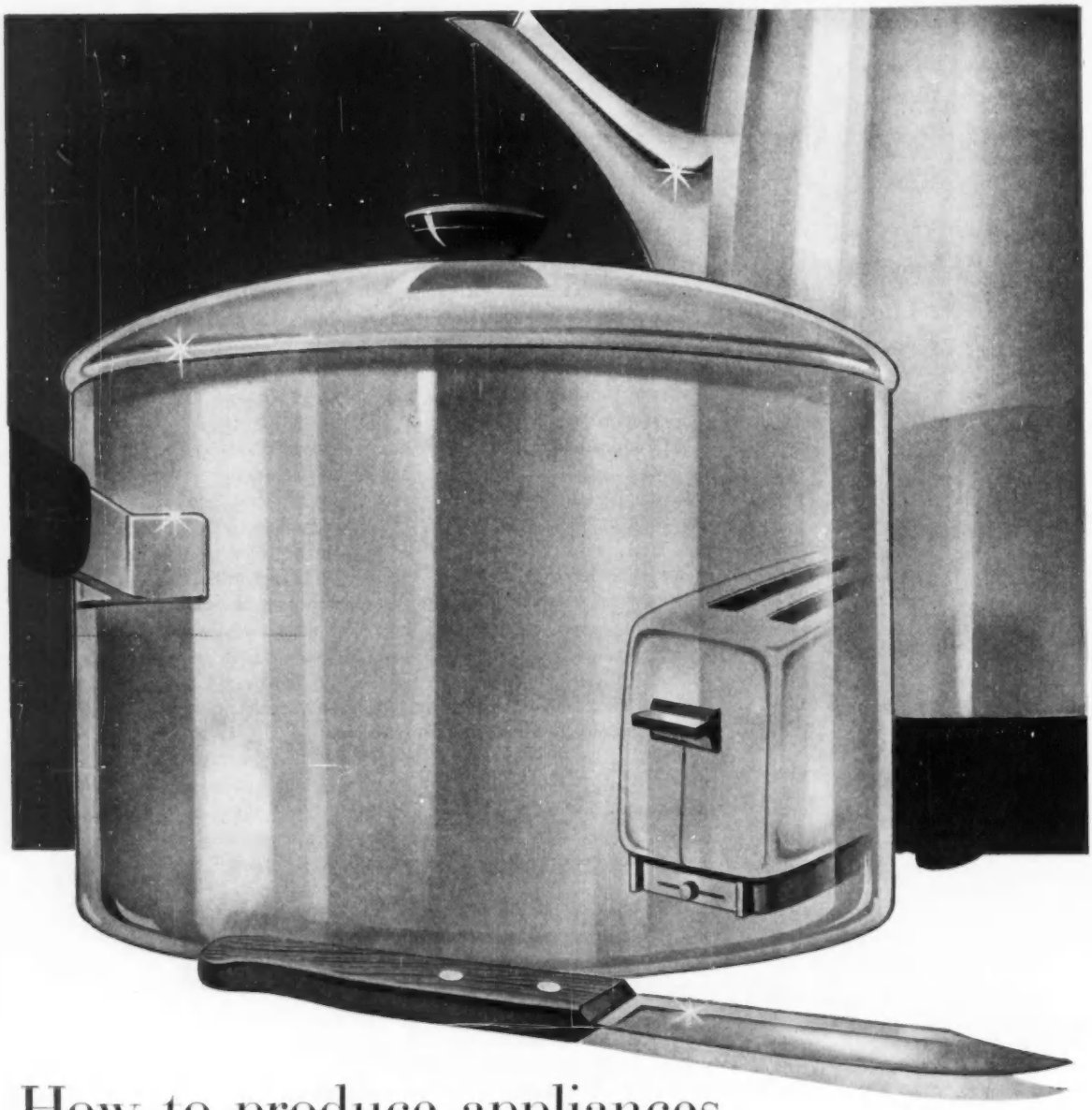
Research Approach Is Different

That the universities have been hit, too, appears superficially to have the merit of democratic treatment, and takes the line of thinking that university research, and industrial research and procurement, were designed to achieve the same results. But many university people feel strongly that this is an unrealistic appraisal of their contribution. Their government-supported investigations are generally basic in character—the type of project that pushes through to some new understanding of our physical environment. It is inexpensive in comparison with its results. Or as it has been put, "the only trivial thing about basic research is the cost." But basic research must be a continuing activity. It cannot be turned on and off like a production line, nor can it be produced at will as the need arises.

The Long-term Consequences

The government has become an important—in fact, a major—source of support for basic research in the nation. And most university people recognize the need for cutting government spending. They also recognize that the Air Force is in an extremely difficult position. But the long-term consequences of cutting basic research deeply disturb them; many feel, furthermore, that the cutbacks in university research will not even accomplish the immediate economies toward which they aim. The amount of money the Defense Department pours into basic research is small in comparison with the size of its total outlays and the cut in spending to which the Department is committed. The Air Force Office of Scientific Research, around which most of the controversy has jelled, has a budget of $16 million spread over 650 to 700 contracts. Navy has a basic research

(Continued on page 49)



How to produce appliances with a built-in polish

Stainless is the one metal that maintains its beauty from plant to purchaser. Consumers appreciate its lifetime sparkle . . . carefree durability . . . ease of cleaning . . . substantial feel. And you'll like the clean, dependable way that you can work and form Crucible stainless.

Why *Crucible* stainless? Among the many good reasons are: ***Uniformity***—strip and sheet unsurpassed in flatness and close tolerance control. ***Finish***—fine finishes, in a wider choice. ***Fast Supply***—wider assortment of grades, sizes, shapes—all available promptly through nearby Crucible warehouses.

Join the switch to Crucible stainless. You and your customers will be glad you did. Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.

Write for a free copy of the "Crucible Stainless Fabricator's Handbook".

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budget of $26.5 million. Army has a total research budget of $420 million, and probably 5% to 10% of this goes into basic research. These are relatively small amounts and their elimination would fall far short of the Department's objective: to cut spending by $2 billion.

Furthermore, a disturbance now in continuity of the programs will serve to increase their costs as they are reactivated. An administrator at the University of Michigan Engineering Research Institute has pointed out that each student who leaves the university because of cutbacks carries with him a certain amount of training and know-how. Restoration of the program will not bring back the engineers who were working on it originally. New people can be trained, of course, but at an expenditure of time and money far greater than savings the cancellations can effect.

One Opinion

These long- and short-term consequences of government action have aroused strong feeling. For example, Dr. Antonio Ferri, Director of the Aero Dynamics Laboratory of Brooklyn Polytechnic Institute, has this statement for *Product Engineering:* "I am in strong disagreement with the sudden and drastic nature of the recent curtailments in the sponsorship of research by the agencies of the Department of Defense. I believe that these curtailments, and the manner in which they have been made, will seriously damage the research effort and the consequent technical advancement of the United States, both from a short-term and long-range point of view. Although our establishment has been affected to a more moderate degree than some other laboratories, this continuous research instability will reduce our research capabilities and force our activities to proceed on an increasingly limited scale. It is very difficult to assess the long-range consequences of the aforementioned contraction in terms of both money and research advancement. I believe that when the over-all effects are considered for a long period of time, it will be found that a substantial increase in cost will result. This would be more true if an emergency should arise."

Graduate Student Program Hit

There are other less obvious ramifications to the cutbacks. Creation of a large number of research projects has afforded the universities a unique opportunity to teach promising advanced students by allowing them to work along with scientists on important projects. Many students depend upon the small incomes they earn this way to cover part of their tuition expenses. Elimination of the projects will therefore affect both the quality and quantity of young scientists.

Universities Strapped for Funds

Commenting on the financial bind, Dr. Oram C. Woolpert, executive director of the Ohio State Research Foundation, has said: "We have just been asked to accept deferrment of payment for some agencies until after the first of the year. We have reluctantly agreed to do this. Obviously, we can't carry these costs very long for many research contracts without going out of business. We can do so only as an interim measure. We are carrying on some programs in the belief that an extension or a new contract will be forthcoming. If neither comes, we are out of pocket. In other instances we have contracts and funds, but the agencies won't pay for costs incurred under the usual schedule. This, too, means money out of pocket."

The threat of dismissal has been hard on the morale of many university scientists, who are already underpaid by the standard of earnings in other professions. Many will be reluctant to accept government work again, though the need for their services becomes urgent. This attitude may linger long after the situation stabilizes. —Paul Anderson

FACTS

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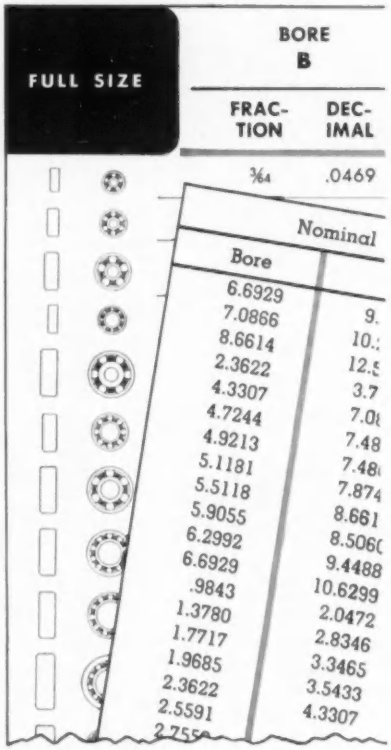


Turbine bearings with two-piece inner rings in bore sizes from 25 to 220 millimeters. Send for New Departure catalog ABC.

Precision instrument bearings in bore sizes from 3/64 to 3/8 inch. Send for catalog PIB.

NEW DEPARTURE

DIVISION OF GENERAL MOTORS, BRISTOL, CONN.

NOTHING ROLLS LIKE A BALL

Product Engineering

October 28, 1957

Career Insurance

Graduate degrees in engineering, permitting and accrediting specialization, are one obvious and necessary answer to two pressing problems; technical manpower needs of our increasingly complex economy, and recognition for the engineer. But graduate schooling is hard to get and harder to pay for. The attractions of immediate and lucrative employment, the overload on trained personnel, and the requirement for military service all conspire against further schooling.

Many industries have sought a solution by cooperative off-hour arrangements with local colleges, or even by sponsoring promising men for as long as a year in advanced training. Many have imported professors to teach special courses. But Hartford has found a much more practical answer (Oct. 14, p. 111).

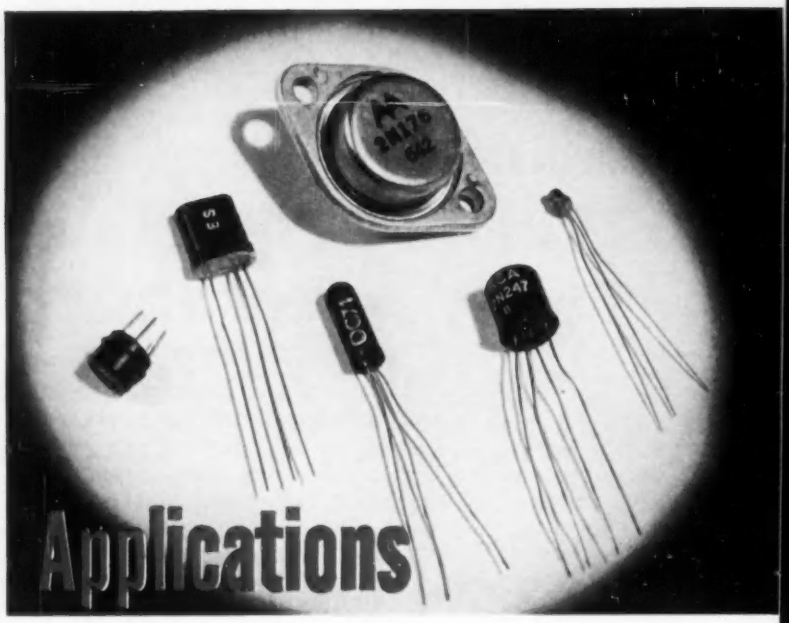
Specifically, United Aircraft spent more than $625,000 to convert a former shopping center into a graduate school operated by Rensselaer Polytechnic Institute, Troy, N. Y. It has a faculty of 40, offers MS degrees in 10 major technical fields, and has an enrollment of 450 as its third year opens. Students take two evening classes a week, can complete the required 30 credit hours in five semesters. Cost is $65 per credit hour, but the check for $1950 per degree is, in 99% of the cases, being picked up by UA and the dozen other local companies who send men there. They also pay any deficit. Among well-known names represented are Chapman Valve, Combustion Engineering, Electric Boat, Fafnir, Gray, Monsanto, New Departure, Trumbull, and Westinghouse. Combustion Engineering even placed its Nuclear Research Division in Hartford because of the school.

Sponsoring companies claim they're getting their money back in ease of recruiting good men and in better work by participants. Classes begin at 3:45 pm and run through the evening, so there is little interference with the working day.

Hartford is of course known nation-wide as "The Insurance City." Thus the location is singularly appropriate, because a plan providing advanced technical degrees is a plan for career insurance. In this instance, however, it was industry that discovered and sponsored the program, not the insurance companies, and the insurance is for a better life for the insured, not compensation for his heirs. His premium is only time and effort.

Note that "big industry" conceived the idea, implemented it, and is picking up the check. A far cry, this, from the demagogue-publicized picture of big business as a nickel-nursing, soulless octopus, submerging individual initiative in corporate expansion and profit.

Transistors vs Tubes for Industrial Applications



Size range . . .
of typical transistors, here about actual size, shows that standardization has not yet arrived. Largest is a 3-watt Motorola power transistor. Others (from left) are made by: GE, Raytheon, Amperex, RCA, and Philco, the smallest, which has about 5-milliwatt output.

A STAFF REPORT

Transistors have been touted as the successor to electronic tubes. But along with outstanding advantages, they have some significant limitations. Here are the facts . . .

Invention of transistors in 1948 started a revolution in the field of electronic amplification unequalled since the advent of De Forest's triode vacuum tube 50 years ago. A current survey by Stanford Research Institute indicates that this year's production of about 25 million units will increase to 125 million transistors in 1959, with 49 million of them for industrial applications.

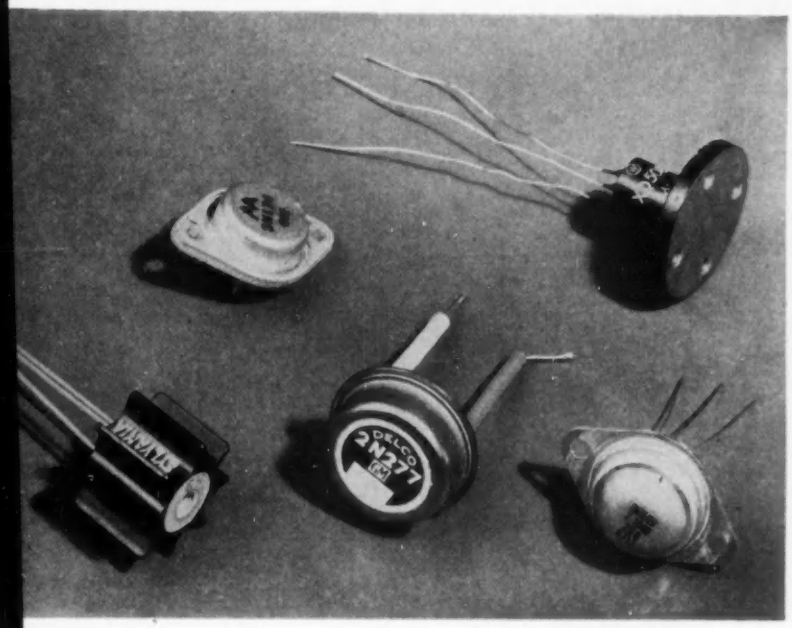
Transistors are available for four principal applications where tubes have been used: low-frequency amplification, high-frequency amplification, switching, and high power output. While a substantial proportion of the low- and high-frequency types are now used in entertainment and communication equipment, applications in industrial electronic circuits are growing. High-frequency types are suitable for low-power switching and pulsing, in counting circuits and computers. Power transistors are used principally for low-frequency amplifiers and for driving motors in automatic control systems; the trend includes some transistors designed for high-power switching service.

Transistors are smaller, more efficient and more durable than vacuum tubes.

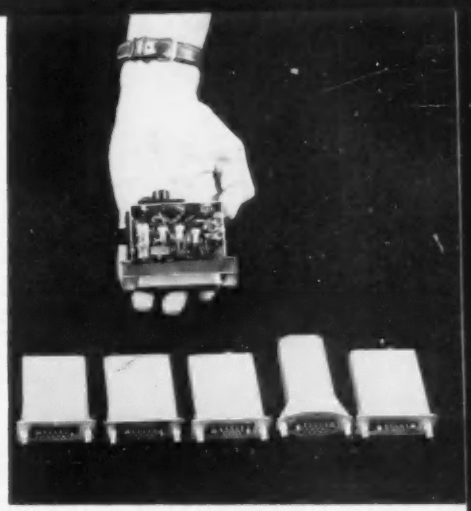
Size . . . Amplifying function in a transistor takes place in a minute volume of material—pinhead size. Even after adding necessary structural support, leads and mounting means, the physical size is only a small fraction of the volume required for a comparable electron tube.

Efficiency . . . Transistors can operate with an electrical efficiency of 50% or better; 75% in some types of amplifiers. For cathode-type electron tubes, efficiency ranges from less than 5% to as high as 10%. Tubes require continuous heater power—transistors require none; the tube is a high-resistance device with substantial internal losses—the transistor is low resistance and has low internal loss.

Compatibility . . . Tubes generate power at high voltage and low current, often requiring amplification before useful work can be obtained from them; by contrast, transistors are high-current devices, therefore



Heat dissipation methods . . .
for power transistors are varied and ingenious. To keep the sensitive junction at safe operating temperature, tendency is to provide a large heat sink with generous surfaces for conductivity or radiation to a cooler medium.



Remarkable miniaturization . . .
is possible where heat dissipation isn't a problem. The tranistorized Westinghouse servo amplifier (held in hand) replaced the five tube-type units below. Weight was cut from 33 to 4 oz. Fewer components were needed—39 for the original, 24 for the new. Six tubes were replaced by 5 transistors; power consumption reduced from 40 to about 1 watt.

more readily adapted for direct operation of contactors, solenoids, clutches and motors.

Contrasted with tubes, transistors can be turned on instantly and require negligible standby power. They can be powered by low-voltage batteries—1.5 to about 28 volts—while power-amplifier tubes require voltages of 250 to 1000, or even higher.

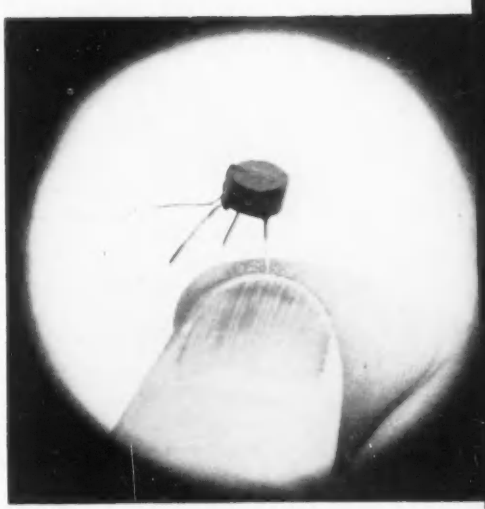
Durability . . . Transistors do not fail from exhaustion, as do tubes. Unless abused or overloaded, operating characteristics do not change during life. Some early types underwent change with time through contamination by moisture, but effective hermetic sealing has eliminated this problem.

Shock or vibration has less effect on transistors than on tubes. Transistors are simple, solid structures with inherently good strength and rigidity. Some types will withstand shocks of 500 g and steady loads of 20,000 g in a centrifuge.

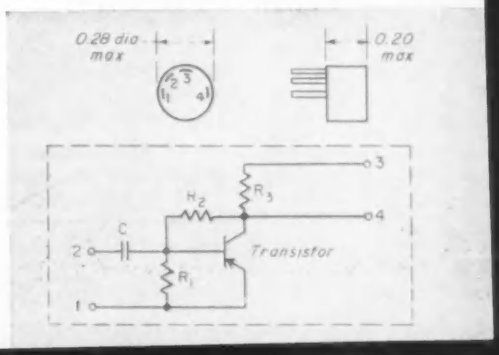
BUT THEY MUST BE KEPT COOL

Main limitation of the transistor is the damaging effect of elevated temperature, whether in storage or in operation. The upper limit for germanium transistors today is 85 to 100 C, and for silicon, 150 to 175 C. Operation above these temperatures causes a continuous and permanent reduction in performance until the transistor no longer functions as an amplifier, but merely acts as a conductor. If the temperature is raised high enough to destroy the junction terminals, failure is complete.

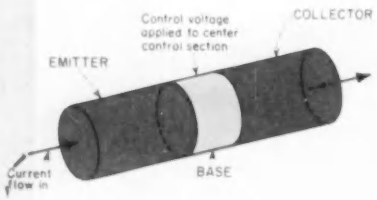
The amplifying property of germanium transistors is

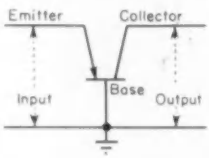
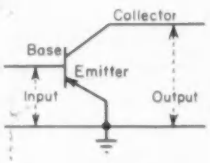
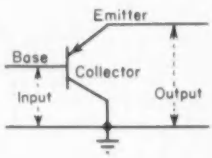


Complete packaged amplifier . . .
made by Centralab is less than 9/32-in. dia, with transistor, capacitor, 3 resistors and 4 leads, connected and encapsulated. Voltage gain is 21 db at 1-mw output; current drain on 1.3-v mercury cell is only 0.5 ma.



Three Basic Ways of Connecting Junction Transistors



Operating Characteristics	Common Base	Common Emitter	Common Collector
			
Resistance, ohms			
Input	100	600	600,000
Output	500,000	60,000	60
Gain			
Voltage	150	600	Less than 1
Current	0.96	25	25
Power	400	6000	Less than 1
Signal phase at output	Same as input	Voltage phase reversed	Current phase reversed
Advantages	High output resistance	High output resistance; high voltage and power gains	High input resistance; high current gain
Limitations	Low input resistance	Low input resistance	Low voltage and power gains

What They Are, How They Work

A transistor is a small piece of semiconducting material, such as germanium or silicon, to which three electrodes are attached. It can be considered as a conductor with three sections in series: an input section (emitter), a central control section (base), an output section (collector), as in diagrams above. The base corresponds to the control grid of a vacuum tube, the emitter to the cathode, and the collector to the plate.

By applying an ac or dc control voltage to the center, a dc current flow through the device can be reduced or increased. Since a substantial flow of output current can be controlled by a signal of quite low voltage and current, the device functions primarily as a current or power amplifier.

Three commercial types have characteristics useful in industrial control circuits: point-contact, surface barrier and junction. Differences are mainly in the manufacturing methods employed in producing the junction between a tiny germanium or silicon wafer and an indium dot or a fine bronze wire.

Point contact type has two 5-mil bronze wires welded side-by-side to the wafer with the welds separated by about 0.002 in. Power capacity is limited to milliwatts by the small size of the junction and the limited volume of material in the contact zone. Principal advantage is high amplification at high frequency.

Surface barrier transistors have leads connected to opposite sides of a wafer section etched to a thickness less than 0.0005 in. The surface is plated with indium and leads are attached. Gain and maximum frequency are in the same range as in the point-contact type; power capacity tends to be a little lower, often under 5 milliwatts.

The junction type can handle watts of power because the contact areas are large. The junction is made by fusing and diffusing the indium disk into the wafer. Power gain is in the range of 1000 to 10,000 with power output up to 20 watts with adequate heat dissipation.

Transistors can be connected with either the base, the emitter, or the collector common to both input and output circuits. Performance characteristics are different for each connection, as shown in the table above for junction transistors.

SOME TYPICAL APPLICATIONS

Machine-tool control console . . .
developed by Autonetics employs printed-wiring boards with transistors.

Battery-powered cardiac monitor . . .
has packaged transistor circuit requiring only 3-v supply—danger from spark ignition of ether is eliminated.

a maximum at about 25 C. Performance decreases at both higher and lower temperatures; below −40 C, operation is seriously impaired.

The decrease in amplification at elevated temperature may be offset by bias and temperature-compensating circuits, but constant amplification can be obtained only at a reduction in gain and power output.

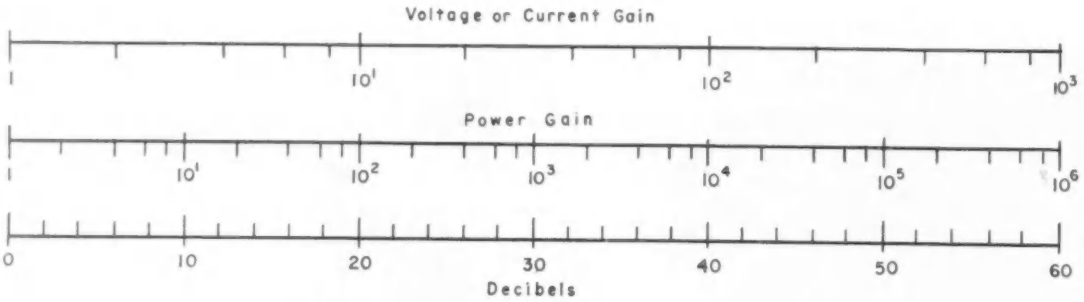
AMBIENT OR SELF-GENERATED HEAT

Two sources of heat affect transistor operation: ambient temperature, and heat generated in the transistor by current flow. Where the temperature of mounting surfaces or ambient air exceeds safe values, fans or blowers can help dissipate heat. Whatever the means used, the transistor junction must be kept cool.

With low-power transistors, the cooling problem is usually easy to solve. For power transistors, however, the operating temperature of the junction is the limitation on power output. Ratings always include max junction temperature; specifications give the junction temperature rise per watt of power, and allowable power for a given transistor-case temperature. With these data the size of the heat radiator can be determined.

Because of the cooling problem, transistor power amplifiers may require more space than equivalent vacuum tube circuits. The allowable operating temperature of a transistor is 250 to 300 C lower than for a tube, and

Outdoor warning flasher . . .
has transistor timer using so little current that batteries will last for 1200 hr.



Decibels vs gain . . .
A quick conversion chart for units of power, current and voltage.

the rate of dissipation is much less; consequently, for a given power output the radiating area required to dissipate the heat from a transistor is substantially larger than for a tube. When transistors are used with tubes, the transistor must be protected from heat radiated or conducted from tubes.

TRANSISTOR RATINGS

Maximum allowable temperatures usually are the same for operation or for storage. While operating-temperature limits apply to the junction rather than the case, the limit is normally given for the mounting base because of difficulty in determining the internal junction temperature.

Another phase of the temperature problem is presented by voltage surges or transients which may momentarily raise the temperature above safe values. Normal operating voltages therefore are much lower than maximum voltage ratings. For example, a transistor for a 12-v supply has a maximum rating of 60 v. Because of sensitivity to voltage surges, transistors normally cannot be replaced while equipment is in operation.

Sockets are not recommended for power transistors because of the need for good heat transfer. Also, resistance of the socket contacts can be higher than the minimum internal resistance of the transistor, and power loss in the socket connection can generate unwanted heat at the transistor leads.

OUTPUT CONSIDERATIONS

Tubes far surpass transistors in power capacity because the size of vacuum tubes can be made as large as required–almost without limit. Tubes manufactured today can produce as much as 500,000 w output at high frequencies. The state of the art today limits transistors to about 15-amp current and 20-w power.

Another limitation of transistors is the relatively high self-generated "noise" level. Even when controls are set for no output, a small current of random frequency flows. Where high amplification is needed, the noise from an earlier stage of amplification may mask the input signal and thus limit the amount of amplification obtainable.

Amplification or power gain is commonly specified in decibels, which is sometimes confusing even to the expert. The chart above simplifies conversion.

For Your Library

For more information on theory, fabrication, and circuit design, the editor recommends:

Handbook of Semiconductor Electronics, by Lloyd P. Hunter; McGraw-Hill Book Co. Excellent practical manual that covers physics, technology, and circuit design.

Transistor Circuit Engineering, by Richard F. Shea; John Wiley & Sons, Inc. Comprehensive discussion of circuit theory in all fields including amplifiers, oscillators, pulsing circuits and others.

Transistor Electronics, Lo, Endres, Zawels, Waldhauer, and Cheng. A good circuit-design book which covers much of the ground covered by Shea.

Transistors Handbook, W. D. Bevitt, Prentice-Hall, Inc. A circuit-design book simpler in approach than the above.

Acknowledgement

Many sources including the suppliers in this list and those mentioned in captions contributed in the preparation of this article. Other collaborators included Allis-Chalmers and Signal Corps Engineering Laboratories.

Current Sources for Transistors

The field is moving too fast to hope that this list of transistor ma· fa··turers is complete but it will offer a good starting r

··ex Electronic Corp., Hicksville, L. I., N. Y.;
·.·.oix Aviation Corp., Eatontown, N. J.;
Centralab, Milwaukee, Wis.;
Clevite Transistor Products, Waltham, Mass.;
CBS-Hytron Div., Danvers, Mass.;
General Electric Co., Syracuse, N. Y.;
General Transistor Corp., Richmond Hill, N. Y.;
Delco Radio Div., Kokomo, Ind.;
Germanium Products Corp., Jersey City, N. J.;
P. R. Mallory & Co., Indianapolis, Ind.;
Minneapolis-Honeywell Regulator Co., Minneapolis.
Motorola, Inc., Phoenix, Ariz.;
Philco Corp., Lansdale, Penn.;
Radio Corporation of America, Somerville, N. J.;
Raytheon Mfg. Co., Newton, Mass.;
Sarkes Tarzian Inc., Bloomington, Ind.;
Sprague Electric Co., North Adams, Mass.;
Sylvania Electric Products, Woburn, Mass.;
Texas Instruments Inc., Dallas, Tex.;
Transitron Electronic Corp., Wakefield, Mass.;
Tung-Sol Electric Inc., Newark, N. J.;
Westinghouse Electric Co., Pittsburgh, Pa.

Exhaust parts fight diesel corrosion with . . .

HOT-DIPPED ALUMINUM COATINGS

HERBERT L. KEE, *Chief Metallurgist*
Arthur Tickle Engineering Works, Inc., Brooklyn, N. Y.
Now Assistant Editor, Product Engineering

Aluminum hot-dipping, now easier, lets you substitute less-costly materials, lowers fabricating costs, and reduces maintenance.

The strength of steel can be coupled with the corrosion resistance of aluminum by coating steel parts with a bonded, impervious layer of aluminum. Aluminizing is accomplished by a number of different processes generally based on a coating process followed by a thermal bonding. Hot-dipping differs in that the coating and bonding occur simultaneously. Recent developments in making this process easier have emphasized its advantages, such as low distortion.

Basic steps are cleaning the part to remove oxides, immersing the part in a bath of molten aluminum, removing it from the bath, and eliminating excess aluminum. To meet particular needs, there are variations of the process that involve special cleaning cycles, preheating, fluxing before and after dipping, centrifuging to remove excess aluminum, and heat treatment to promote diffusion of the aluminum layer into the steel.

Protection given the steel has its limitations, of course. Salt-water atmosphere will cause the aluminum to corrode because the coating is anodic to the base metal. But the corrosion rate is about four times slower than that of zinc. In oxidizing atmospheres and dilute oxidizing acids, its corrosion resistance is much greater. But because the coating is cathodic to steel, it must be free from porosity or bare spots.

Although steels and other ferrous metals account for most materials dipped, metals with melting points above 1400 F and with low solution rates in molten aluminum can also be coated. However, silver, lead,

WHAT HOT-DIPPED ALUMINUM COATINGS CAN DO

Conditions They Resist	Base Material	Specific Applications	Remarks
Salt-water atmosphere	Cast iron, carbon steel, low alloy steel	Electrical insulator caps Outdoor transformer cases Steel casement windows Steel wire cores for aluminum conductor cable Gas and diesel engine mufflers, exhaust manifolds and exhaust pipes	Galvanic protection for iron and steel (two to four times life of zinc-galvanized steel)
Industrial atmosphere, outdoors Sulphurous acid Condensates from combustion products	Cast iron, carbon steel, low alloy steel		Replacement for stainless steel Up to 20 times life of zinc-galvanized steel Coating usually cathodic to steel
Scaling, oxidation up to 1800F Carburizing of fixtures and furnace parts	Cast iron, carbon steel, low alloy steel	Gas and diesel engine exhaust valves Diesel engine piston heads Radiant heater tubes Carburizing boxes and spacers Oil refinery catalytic reformer reactor parts	Coating must be heat-treated to convert entire coating to iron-aluminum alloy Replaces stainless steel Aluminized cast iron grows during service
Corrosion by metallic residues in bunker C leaded, and high-energy fuels at temperatures up to 2500F	Stainless steel	Boiler parts Superheater support brackets Gas turbine combustion chamber liners Jet engine afterburner components Radiant heater tubes	Replaces nickel-base and cobalt-base alloys Diffused coating
Loss of long-time physical properties at 1500 F or higher	Nickel base alloys containing boron, titanium, aluminum	Gas turbine blades	Gives longer life Allows use at higher temperatures Diffused coating is barrier to oxidation of precipitating agents
Coking of plastics and hydrazine	Low alloy or stainless steel	Plastic reactor vessels Rocket fuel auxiliary power units	Superior to most metals Diffused intermetallic surface does not catalyze coking

tin, zinc, aluminum and copper cannot be treated, nor can nickel-base alloys with nickel content above 80%, and soldered and silver-brazed assemblies. Copper-brazed and nicrobrazed assemblies are not recommended.

Shape of the part must be considered too. If there are air entrapments to oxidize the material before it comes in contact with aluminum, it will not coat. Avoid such air traps as holes, lap joints, porous materials, and welds with incomplete fusion. Specifying a process that uses flux will allow more flexibility in selecting shapes because the flux will wet surfaces that are partially oxidized, and permit coating.

Less distortion is caused by aluminum dipping than by other coating processes for high-temperature protection. Reasons for this are:

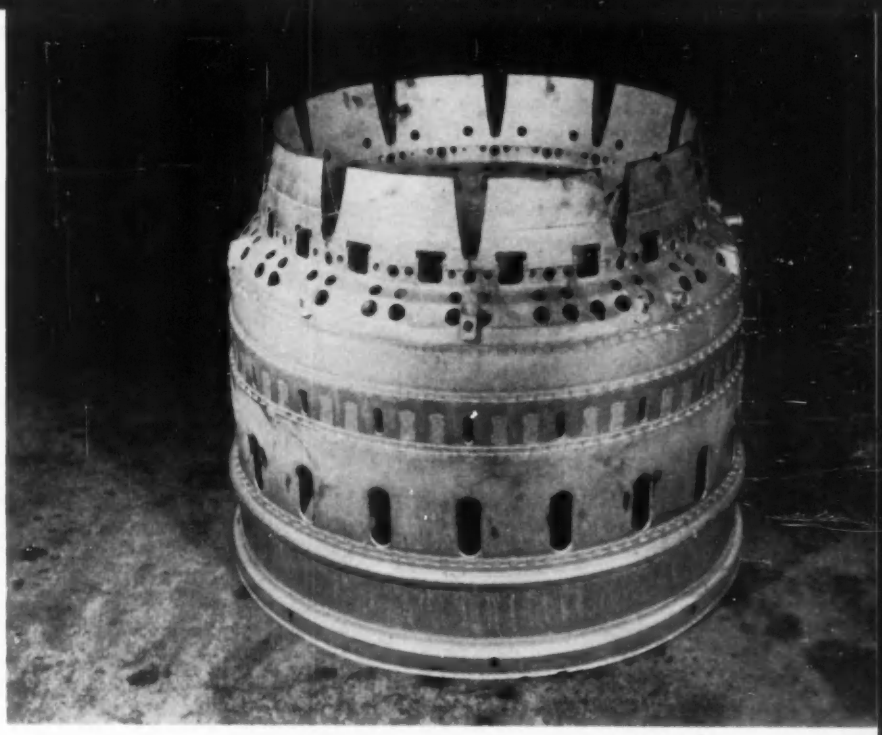
- Dipping temperatures are between 1300 and 1400 F compared with 1800 to 1900 F.
- Weight of parts supported at such temperatures causes distortion in any case, but in the hot-dip bath, weight is decreased one-third by the buoyancy of the molten aluminum.
- Liquid heats the part much more rapidly and uniformly. A 2-in.-thick section can be heated to 1300 F in 2 min.

To take advantage of the low-distortion characteristic requires careful design, and heating parts directly to the dipping temperature. Distortion will occur when thin sections are restrained by heavy sections. In general, a part that has a cross section up to five times thicker than that of another section can be dipped with no distortion; if between five and 10 times thicker, there may be distortion, above 10 times thicker, all parts should be examined for points where thin sections are restrained by the very heavy sections.

Parts and welded assemblies should be stress-relieved prior to dipping. Usually, rectangular shapes with large radii at the corners of fabrication will distort less than rectangles with small radii, and cylindrical surfaces held vertically will distort less than rectangular shapes.

Proper suspension of parts will both decrease distortion, and facilitate drainage of the molten aluminum. Parts should be so arranged that large flat surfaces are held vertically to present least resistance to the aluminum on entering and leaving the bath. Long, thin parts should be suspended with the long dimension vertical and suspension points should be attached to the stiffer vertical surfaces. For example, suspend from the shorter sides of a rectangle rather than the longer sides or the corners.

Post-forming of parts dipped with pure aluminum is difficult without cracking the coating. However, addi-



Jet engine liner . . . shows typical application for aluminum coating. It slows damage from hot exhaust gases.

tions of silicone and beryllium will increase ductility of the bond for fabrication. Aluminized pipe can be bent around a 5-in. diameter. There are no problems in minor straightening of pipe after welding and stress-relieving.

Welding methods are available for joining coated parts. Simplest is to remove coating, weld normally, and spray-aluminize the joint. For piping, special designs using backing rings permit welding without subsequent repair of the coating. Welding without stripping coating requires a diffused coating. Stainless steel rod on diffused coated surfaces can also produce satisfactory joints. As yet, however, welded joints using diffused coatings are not permitted by pressure vessel code.

Brazing aluminum-coated material is like brazing solid aluminum. Recent developments proved the practicability of welding aluminum-coated steel to solid aluminum.

Threads, when aluminized, tend to form fillets at the roots, preventing good fit. Threads should be machined or chased after dipping, rather than masked, because masking costs are high. Centrifuging can clear male threads, but female threads must be chased.

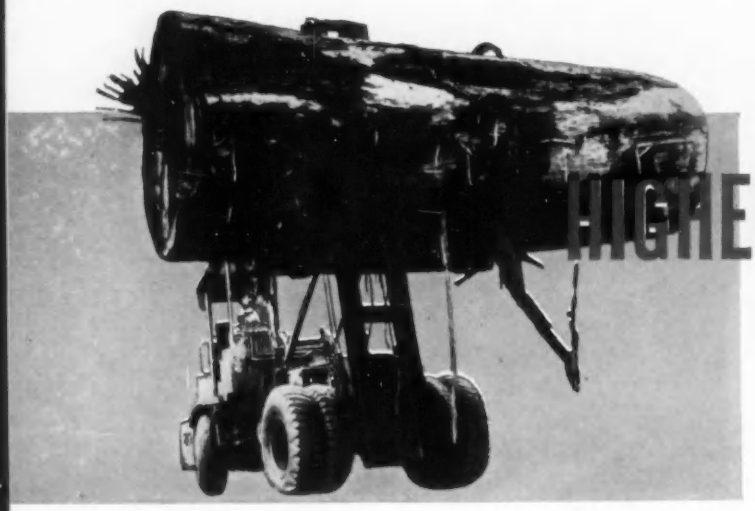
Coating thickness includes the intermetallic alloy and the aluminum overlay—a total can run from 0.001 to 0.010 in. Almost all of the alloy layer is formed by diffusion of aluminum into the base metal. For outdoor use, a heavy aluminum overlay (0.005 in.) is preferred. Diffused coatings require a thin overlay (0.001 in. max) to prevent spalling during diffusion treatment. For optimum ductility, both the alloys and the overlay should be kept to a minimum.

Thickness of the intermetallic is a function of time, temperature, composition of base metal, and bath composition. For example, carbon steel dipped in commercially pure aluminum at 1300 F forms a coating at 0.002 in. per minute of reaction. For low-alloy steel, the rate is about 0.001 in.; for stainless steel of the 18-8 variety, about 0.0007 in.

Overlay thickness, on the other hand, is dependent on drainage of aluminum as parts leave the bath, and is therefore more difficult to control than the intermetallic layer (special techniques can be used to remove the variable overlay, leaving the readily controllable alloy layer). This is because thicker parts take longer to cool and allow more time for aluminum to drain. After aluminum coating has solidified, heat remaining in the heavy sections produces thicker intermetallic at expense of overlay. For uniform coating, maintain uniform part-thickness; if this is not possible, specify a higher thickness.

Costs of commercial aluminum dipping are from three to five times those of galvanizing, or from 10¢ to 40¢ per lb. Because of price differential, aluminizing cannot be considered a cheaper substitute for zinc galvanizing. However, the coating becomes economically desirable for temperatures above 800 F, where zinc coating will not give necessary protection. Aluminizing should be used where corrosion contaminates products, poisons catalysts, or precipitates materials that clog pipes and systems. It will prevent costly downtime for equipment operating in remote locations or where replacement costs are high. The accompanying chart lists other applications.

EDITOR'S NOTE: This article is one of a series on corrosion resistance and high-temperature protection. Other pertinent articles are: "Fluidized Plastic Coatings for Corrosion Resistance," Jan '57, p 140; "Corrosion of Dissimilar Metals," Dec '56, p 187; "Chromizing for Resistance to Corrosion and Wear," Nov '56, p 180; "Developments in Sprayed Metal Coatings," June 56, p 194.



why not HIGHER PRESSURES for mobile hydraulics?

Strong-arm jobs . . .

don't trouble this Herculift for which Hibbard-Riley & Associates designed a 6000-psi circuit. The machine is carrying a 25-ton log on a 7½-in. ram.

WESLEY R. MASTER
Director of Engineering, Dynex, Inc.

In many applications, 3000- to 6000-psi circuits are no more expensive than lower-pressure ones. They take less space, move faster, and use power more efficiently.

Bulldozers, scrapers, loaders and similar mobile construction equipment expend a large percentage of their total power in operating hydraulic accessories. Traditionally these circuits have been designed for 800 to 1750 psi. But now, following the lead of aircraft and machine-tool systems, a shift to higher pressures is developing.

Higher cost of the piston pumps required has always been a strong deterrent to the jump to 3000 psi. They remain more expensive (in dollars per horsepower) than equivalent gear- and vane-pumps. However, cash savings from the lower cost of smaller lines and cylinders in high-pressure systems, particularly in the higher power ranges (over 25 hp), may more than offset increased pump cost, and give bonus in smaller space requirements and faster response.

High-pressure valves, cylinders and associated circuit components are now readily available so complete systems can be designed, and high- and low-pressure circuits compared, system vs system, for economy, least weight per horsepower, and space.

SIZE REDUCTION

• **Cylinders.** A cylinder is designed for a net force output which is a product of piston area and fluid pressure. If pressure is increased from 1000 to 6000 psi, the cylinder area may be reduced by 83%. A 6-in.-dia low-pressure cylinder may be replaced by a 2½-in. high-pressure cylinder. Often a single high-pressure cylinder can replace two low-pressure cylinders. Usually the greatest space saved by switching to high pressure will be in reduced cylinder sizes.

When very small cylinders are involved, high pressures are less practical because the calculated cylinder load is limited by piston-rod column strength. Higher column strengths are attained with alloy steels. Hollow piston rods can also be used, Fig. 1, but the value of this method is controversial.

• **Circuit lines.** Transmitted power is proportional to product of pressure and flow. For the same power output, higher pressures permit considerably reduced flow volumes. Piping diameter can be reduced (even taking increased wall thickness into account) and bend radii can be smaller, simplifying installation.

• **Pumps.** Direct comparison of high- and low-pressure pump sizes is difficult because of their non-uniform shapes. In general, for the same power output, size differences will be small.

• **Valves.** Because flow is reduced by the same ratio that pressure is increased, valves need to port much less oil to do the same job. However, possible size reduction is offset somewhat by increased structural strength required to accommodate the higher pressures. A small net gain in space may be expected.

• **Reservoirs.** Capacity of oil reservoir is usually based on total oil in the circuit, and maximum flow demand. Both are inversely proportional to the pressure so reservoir size for the same power is substantially reduced at higher pressures. This is significant, especially on mobile equipment where unobstructed space is at a premium.

• **Weight** will generally be proportional to size and space requirements. In particular, weight of cylinders

and reservoirs can often be reduced by a factor of two to four. Weight of pumps and valves will be comparable at either pressure.

SPEED AND EFFICIENCY

A highly desirable attribute of high-pressure systems is the livelier response to control. Reduced oil flow results in lower pressure drops in lines, fittings and orifices, and a higher proportion of pump pressure is available at the cylinder. This increases speed of response and makes cylinders more sensitive to value actuation.

It also explains why high-pressure circuits are generally more efficient, less power is wasted in forcing large volumes through the piping.

The ratio of radiating area to cross-section of a pipe line is inversely proportional to its diameter. Smaller lines therefore maintain lower equilibrium temperatures, a definite advantage in any hydraulic circuit.

Further, piston pumps are inherently more efficient than gear or vane units, Fig. 2, so there is less heat generated in the first place.

CIRCUIT COST

Typical construction-equipment circuits (most of them use gear pumps) cost from $18 to $22 per delivered horsepower for systems over 25 hp. Of this total, only $1.50 to $3 per hp (approximately 10%) is spent on the pump.

Piston pumps are, and will probably continue to be, more expensive than vane or gear pumps. But the price gap is closing because high-pressure mobile pumps need not be manufactured to aircraft tolerances, ball check valves can replace rotating valve plates, and wobble plates can replace universal joints.

In equivalent high-pressure circuits, a piston pump will now cost approximately $5 to $9 per hp, but the cylinders are so much smaller that substantial circuit savings are possible. As the number of cylinders used in a particular circuit increases, total circuit cost, Fig. 3, becomes more and more competitive with that of low-pressure circuits.

High-pressure hose and fittings also lead to substantial economies. Investigation of a 50-hp job showed 6000-psi hose cost about half that of 1000-psi hose—result of the significant difference in hose diameter. High-pressure fittings are small enough to be made on high-speed automatic screw machines, whereas larger low-pressure fittings often must be made on turret lathes at roughly double the cost. Smaller reservoirs and less total-system oil also contribute to lower high-pressure circuit cost.

Note that comparisons of this kind should be made on the basis of power output at the fluid motor rather than power input to the pump, because piston circuits are inherently more efficient and for the same output power will require a lower-horsepower pump.

MAINTENANCE

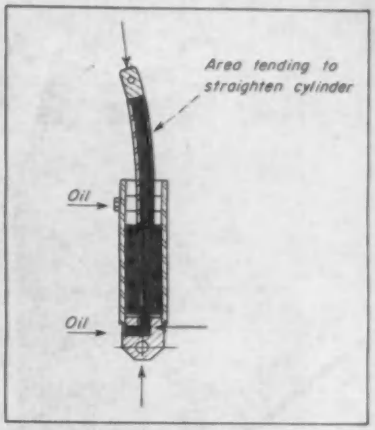
High pressure sounds good; there are many advantages, but what about leakage and bursting lines? Maintenance and assembly men must take a little more care, but if the system is assembled and run for a few cycles, then all fittings are retightened, subsequent leakage problems are comparable with those in lower-pressure circuits.

Piston pumps will now last 4000-hr running time, significantly longer than gear or vane units similarly loaded.

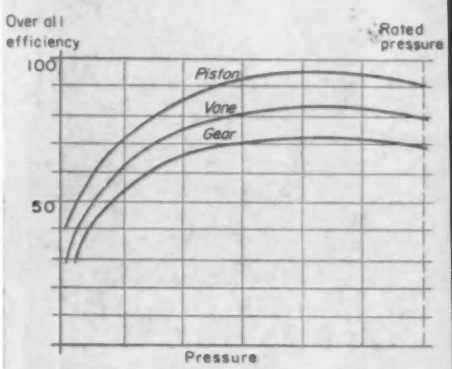
A high-pressure system seldom needs to work at maximum pressure setting. Working pressure varies all through the range and will be at maximum only a small portion of total operating time.

LIMITATIONS

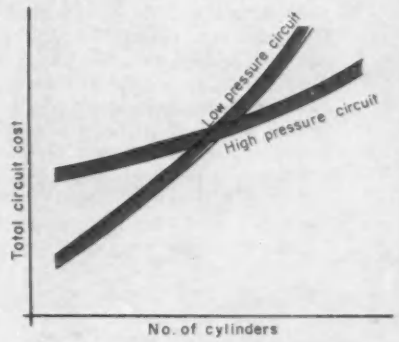
High pressure is not the answer to every hydraulic problem. Fluid compressibility (approximately ½% per 1000 psi) may adversely affect function, as in the precise positioning of cylinders in machine-tool feeds. High pressure is inadvisable when the cylinder becomes too small to function properly as a column.



1 Column strength . . .
for small cylinders may be increased with a hollow piston rod. Bourdon effect of internal pressure tends to resist bowing of rod.



2 Piston Pump efficiency . . .
is higher than vane and gear types over the entire range of working pressure.



3 Cost advantage . . .
of high-pressure over low-pressure systems builds up when number of cylinders is large.

DESIGN FEATURES

POWER UNIT

Turret Rotates Entire Assembly . . .

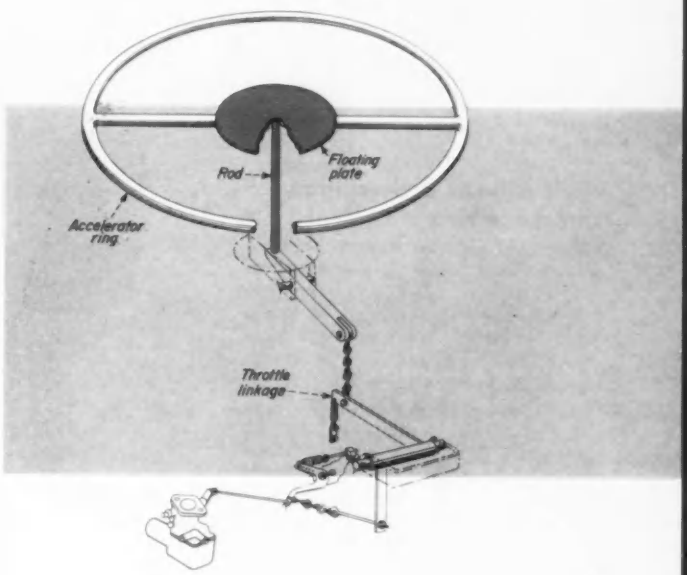
of power and control components—engine, transmission, driving wheel, battery, fuel tank, brakes, generator and instruments. Controls are simple and placed where operator can reach them easily. Engine acceleration is controlled by ring mounted inside steering wheel; depressing this ring opens throttle. Brake lever is on dome over turret, directly in front of operator. It serves as parking brake when latched. Instrument panel (not visible) contains generator light, ignition switch and starter, choke, and engine-hour meter. All turret components are accessible through hinged access doors. Power transmission system consists of centrifugal clutch, variable-pitch V-belt drive, and a worm-gear speed reducer on which the drive wheel is mounted. Clutch, on engine crankshaft inside drive pulley, engages this pulley when engine comes up to speed. Drive pulley has weights that increase pitch dia when centrifugal force moves them outward. An infinite number of ratios between a 3:1 reduction and 1:1.6 overdrive are obtained with this mechanism. Final speed reduction in worm gearing is 26:1. Worm is triple-threaded with a 14½° helix angle and will overrun when operator suddenly decreases engine speed.

Engine Accessories Are on Base Plate . . .

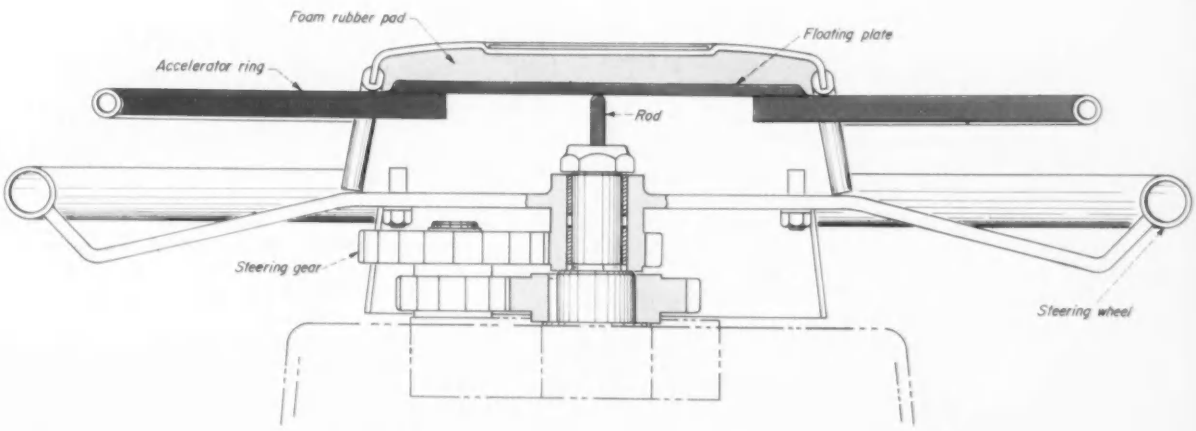
in the structural support for turret dome and spindle. Turret is suspended from spindle on a single, sealed ball bearing. Gear-reduction unit, to which brake and drive wheel are assembled, is bolted to bottom of base plate. Drive wheel is cantilever-mounted, can be removed without disassembling entire drive. Turret assembly weighs about 1000 lb. It is aligned vertically by three rollers, mounted in the chassis, which ride against edge of base plate. Driven by an 8.1-hp air-cooled engine, carrier can transport 4000 lb at speeds up to 9 mph.

Swivels – Reverses Drive

Gasoline engine, drive mechanism, and controls for the new Hyster industrial freight carriers and tractors are in a turret mounted over the drive wheel. Carrier is steered by rotating the turret-and-wheel assembly, which turns through 360° and makes a reversing drive unnecessary. Power is transmitted to drive wheel through a centrifugal clutch and variable-speed belt drive; they form an automatic mechanical torque converter.

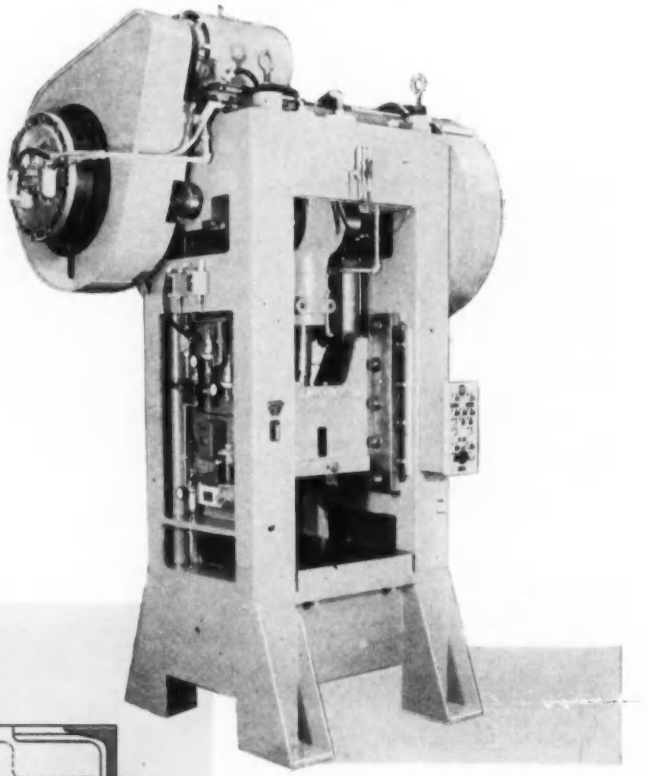


Motion of Floating Plate . . . actuates throttle linkage. Plate floats between foam rubber pad and a rod inside spindle. Depressing the ring at any point causes rod to move up and down and transmit motion to throttle linkage. Chain segments in linkage prevent operator from over-riding engine governor. A 3:1 reduction in the steering gear reduces operator effort when maneuvering. Steering wheel hub is mounted on powdered metal bushing and geared to spindle through a pair of idlers. If direct steering is desired, hub is keyed directly to the spindle.

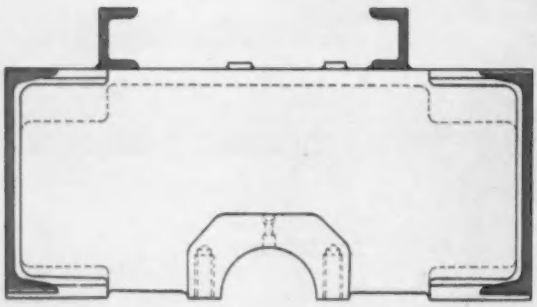


WELDED FRAME WEIGHS LESS, COSTS LESS

By welding steel plates and structural shapes to ductile iron castings to form the frames of 135- and 150-ton presses, the Ferracute Machine Co., Bridgeton, N. J., has reduced the weight of each press by about 8000 lb. Complicated shapes are castings, but simple shapes are weldments of plates or structural sections.

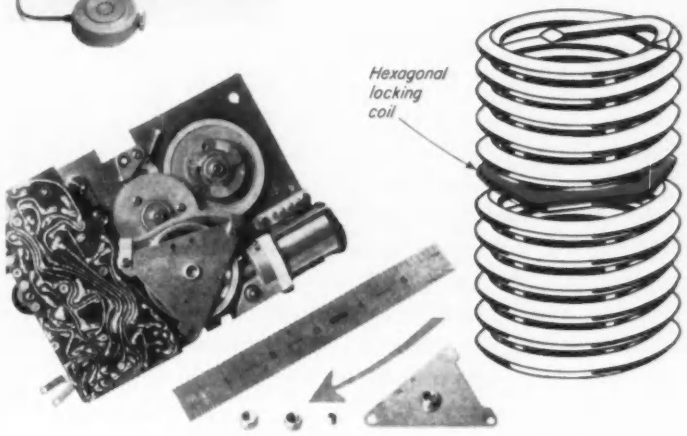


Hollow head and columns contain wiring . . . ▸
and piping for controls, and make a planned installation layout unnecessary for neat appearance. Much installation time is saved in making connections to control boxes and fittings. Holes are cut in backs of boxes, and wiring is brought in through nipples; no piping is exposed at the floor level. Ductile iron is used for the press bed and head-end castings, and for the drive pinion. Press-bed assembly is formed by welding the bed casting to legs made of steel plate. The welded legs are half the weight of legs cast integral with bed.



◂ Press head is assembled . . .
by joining ductile iron end castings with structural steel sections. To reduce cost, castings are rough-machined simultaneously before welding. Welding with Ni-Rod "55" electrodes makes annealing unnecessary.

Wire Insert Simplifies Bearing Adjustment



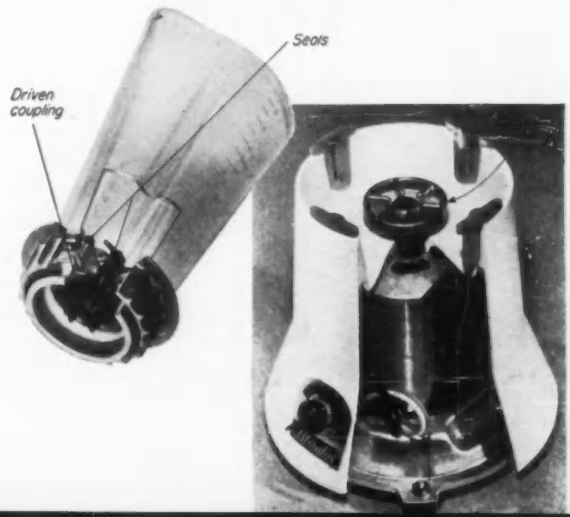
A self-locking wire thread insert, in a bushing that carries a jewel bearing, simplifies setting of shaft end-play tolerance at assembly. Shaft carries the flywheel for tape drive of the Dictet, a portable tape recorder made by the Dictaphone Corp., of Bridgeport, Conn.

Bearings support flywheel shaft . . .
which can have end-play tolerance of 0.002 to 0.004 in. One bearing screw is in the base plate, the other in a bushing pressed into a post-supported bearing plate. Original bushing had no insert and bearing was locked with a jam nut. Tolerance setting changed when the jam nut was tightened, and required several adjustments. With these thread inserts, made by Heli-Coil Corp., Danbury, Conn., only one adjustment is necessary to obtain correct tolerance setting.

Non-metal Parts Featured in Food Blender

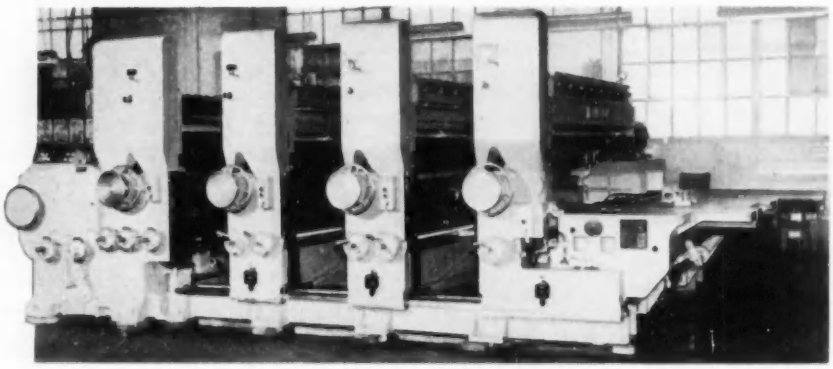
Low cost, quiet operation, ease of cleaning and low heat transfer between motor and food container were basic objectives in the design of the Blendal, a food blender made by Dewenter Industries, Los Angeles, Calif. These goals were met by extensive use of plastics.

Blendal has resilient parts . . .
wherever possible to reduce transmission of motor vibrations. DuPont's Neoprene was selected because the compound could be varied to obtain specific properties for each part; also, it resists atmospheric ozone, is tasteless, and odorless. Neoprene parts include the feet that isolate base from working surface; the shock mounts that suspend motor; the container mounts; the driven half of the drive coupling; seals for container and spindle. Container must withstand high temperatures for short periods; be light and shatterproof. It is made of Dow Chemical's Styrex 767. Base housing is a molded urea compound made by Plaskon.



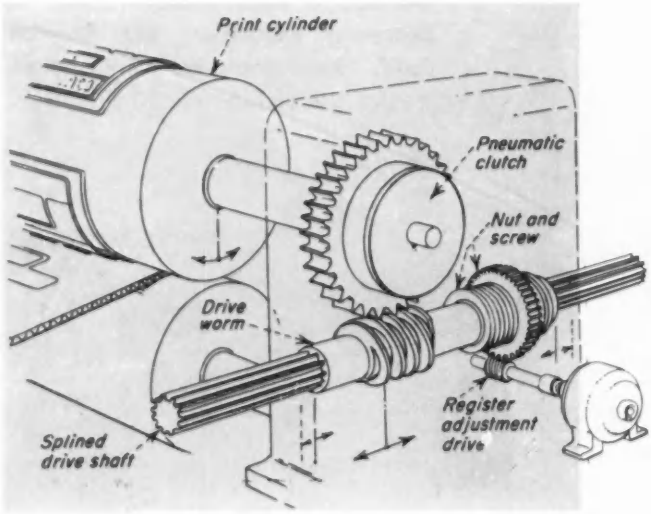
COMMITTEE Guides Design

Suggestions from customers, Management, Sales, Engineering, and Production were evaluated in the design of the Samuel M. Langston Co.'s type 241 printer-slotter. Ideas were analyzed by a management committee of key people from each interested department of the Camden, N. J., company. This committee reviewed the project periodically to make sure these objectives were attained: Press was to be of split construction, and able to print up to four colors with provision for adding coating stations; it should be adaptable to new developments in printing techniques; hydraulic, pneumatic, electrical, and electronic components were to be utilized for automatic controls and safety devices; setup time was to be shortened by incorporating independent variable-speed drives for all fountain functions, and by making adjustment possible with the press in open position.



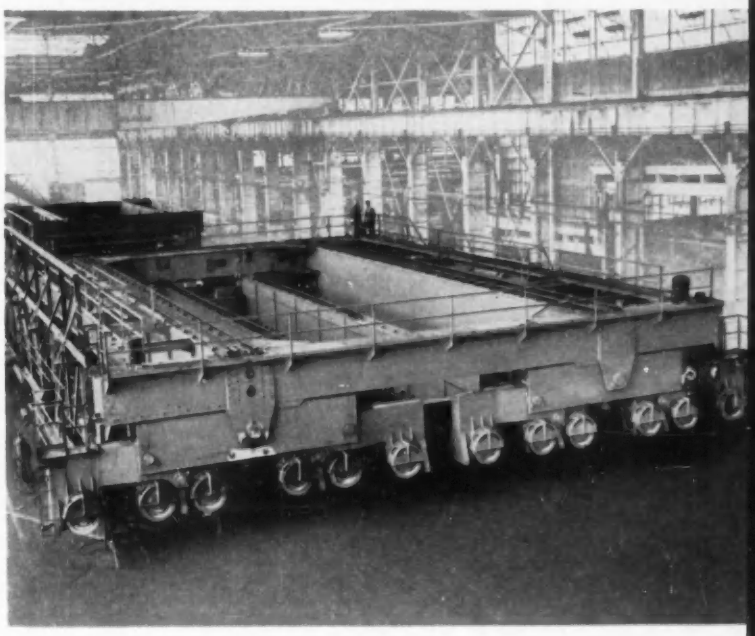
Printing stations separate for cleaning . . .

and setup, and for adjustment. A 15-hp hydraulic pump supplies auxiliary fluid power to actuate all fountain motions, load the lower front feed rolls, and open and close the press. Main drive shaft for printing rolls is in the rear and runs full length of the machine.



A drive that avoided backlash build-up . . .

inherent in long gear trains was required for the four-section, split-construction design because accumulated backlash would seriously affect register. Solution was a splined drive shaft running full length of the machine, with an independent worm-gear power-takeoff at each feeding, printing and slotting station. The worm drives absorb, as thrust, much of the cyclic load patterns of the kicker and slotter mechanisms. Running register of the print cylinders, and the upper slotting shaft is adjusted by shifting the drive worm axially. Main drive motor and slotting station are in the fixed section. Each worm drive includes a remotely controlled pneumatic clutch. Stations can be driven in any position.

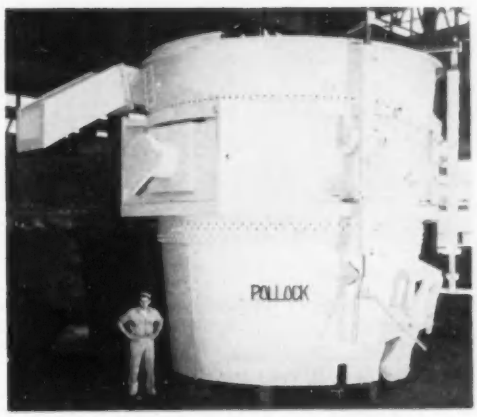


Crane bridge is made of four girders . . .
with a 77-ft span between centerlines of trucks that ride runway rails. The main girders carry the large, 500-ton-capacity trolley; the center girders carry a small, 75-ton trolley. Entire crane weighs 920 tons.

Bridge is designed with all load-transmitting members supported on shelves; all loads are carried in compression. No important stress points are in shear; fasteners and welds carry no loads. Welding instead of riveting the girders reduced weight 15%. Maximum wheel loads of 87,500 lb required trucks to have four wheels and be self-equalizing. Note equalizing pins that distribute load to each group of 12 wheels in truck systems.

BIG HOOK FOR STEEL MILL

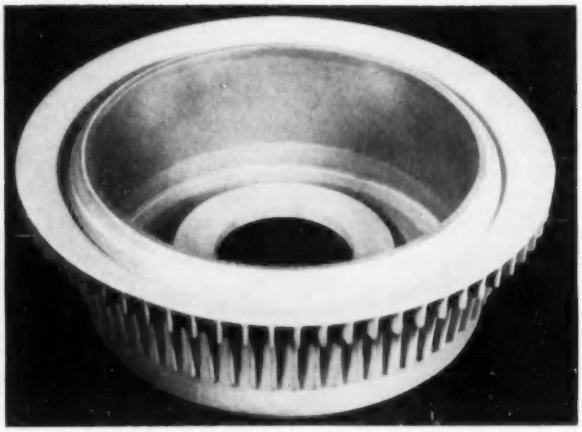
Ladle cranes with a 500-ton capacity, now being erected at Bethlehem Steel Co.'s new Sparrows Point plant, will carry enough steel from furnace to ingot mold in one trip to complete a pour that requires three trips by 250-ton cranes in current use. Designed by the Morgan Engineering Co., Alliance, Ohio, cranes are made of welded steel sections, with automatic submerged arc welding used where practicable. Design required over 10,000 manhours.



Ladle has outside diameter of 17 ft . . .
at top and 13 ft, 10 in. at bottom. It is 17 ft, 3½ in. high and holds 385 tons of molten metal, and was made in three sections by the William B. Pollock Co., Youngstown, Ohio.

Two hooks on crane . . .
support ladle. Each hook is 17 ft, 5 in. long, 7 ft, 3 in. wide, and weighs 34,000 lb. Section is built up of four ⅞-in.-thick and nine 1-in.-thick plate laminations held together by 1¼-in.-dia rivets and welded at the outside edges.

Wear and heat checking from high-speed stops are fought in the Mercedes-Benz SL-300 roadster by lining the aluminum brake drum with 1% nickel cast-iron—a good example of thermal expansion under control. Here's detailed design data on . . .



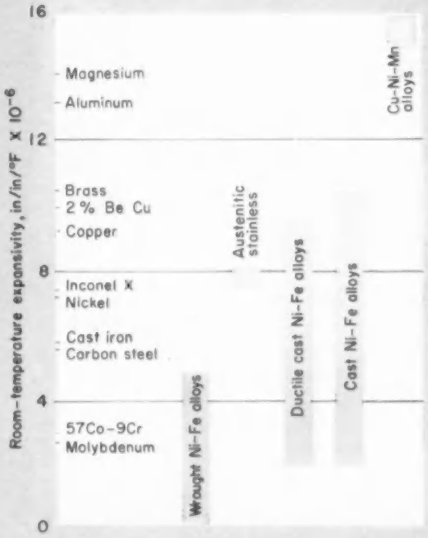
NICKEL ALLOYS for CONTROLLED THERMAL EXPANSION

E. M. WISE
Assistant to Vice President
Development and Research Div., International Nickel Co.

Swings in temperature make it difficult to control critical dimensions in assembled metal parts, particularly when dissimilar materials are used in the same assembly—precision gear trains, for example. Corrosion further complicates the tolerance problem. Nickel alloys provide a potent design tool in these circumstances by combining several levels of corrosion resistance with a wide range of thermal expansion characteristics.

With these alloys, the same operational reliability found in many thermostatic devices can be designed into fasteners, press fits, and hermetic seals—areas where dissimilar materials must operate together over a wide temperature range.

All pure metals expand roughly the same amount between absolute zero and their melting point: about 0.022 in. per in. The softer metals with relatively low



1 Wide expansivity range . . . lends versatility to nickel alloys, compared here to some common engineering materials.

Expansivities of Some Special Expansion Alloys

	Alloy	Composition	Average thermal expansion coef. in. in. °F, 70 F to 300 F	70 F to 650 F
Low-expansion Alloys		31Ni—7Co—Fe	0.3	2.9
	Invar	36Ni—Fe	0.9	3.4
		42Ni—Fe	2.8	2.7
	Kovar	29Ni—17Co—Fe	2.8	2.2
	No. 4	42Ni—6Cr—Fe	3.3	4.7
		38Ni—7Cr—Fe	3.9	6.4
	Dumet	42Ni—Fe (25% Cu-clad)	4.2	3.4
		58Co—8½Cr—Fe	4.3	4.4
		50Ni—Fe	4.8	5.1
	Inconel	79Ni—13Cr—Fe	5.5	6.5
	Low carbon steel	....	6.7	7.5
	"A" Nickel	100Ni	7.5	8.2
High-expansion Alloys	Monel	70Ni—30Cu	8.0	8.6
		25Ni—8½Cr—Fe	9.7	10.2
		18Ni—11Cr—Fe	10.0	10.5
		18Ni—7Mn—Fe	11.3	....
		12Ni—5Mn—3½Cr—Fe	12.2	12.6

melting points, such as aluminum and magnesium, have the largest expansivity (relative change in length per degree); the higher melting point metals—for example, platinum, tungsten, and molybdenum—have expansivities on the low end of the scale.

However, material expansivities usually vary with temperature too, and these variations may be complicated by phase changes. Nonetheless, by careful selection, alloys differing widely in expansivity over a selected temperature range can be made from the common metals.

LOW-EXPANSION ALLOYS

Iron-nickel alloys were among the first used in controlled thermal expansion applications. French metallurgists discovered that certain alloys, in the range 35 to 50% nickel, have exceptionally low thermal expansivity at room temperatures. The cause was unknown but has since been traced to the magnetic characteristics of the alloys.

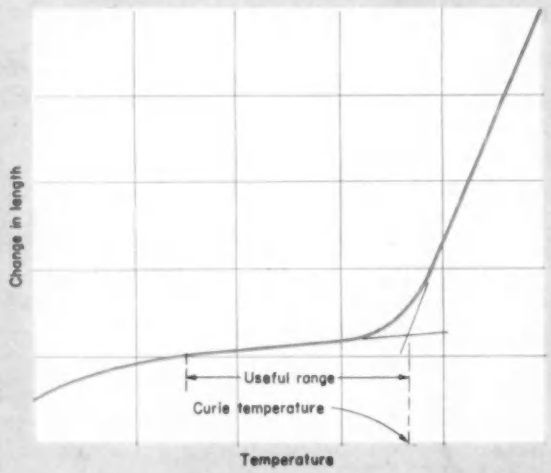
All of the alloys in this category (see table above) are magnetic, and the magnetic interaction is such that they have abnormally high volume per unit weight at room temperature. When these alloys are heated, magnetic forces between atoms decrease and nearly counterbalance the expansion that would normally occur. This compensation is almost complete around room temperature in the 36% nickle alloy, Invar.

Because this low-expansion characteristic arises from ferromagnetic effects, it ceases when the material becomes nonmagnetic. The temperature at which ferromagnetism disappears is the "Curie" temperature. As a result of the sharp increase in expansivity of the low-expansion iron alloys near the Curie point, this temperature is also frequently called the inflection temperature of the alloy. This means that the range of temperature over which low expansivity is desired must be considered, and compromises between minimum expansivity and sufficiently high Curie temperature may be required.

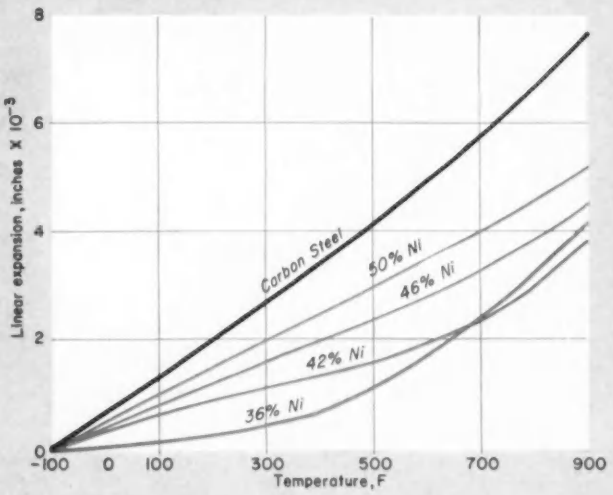
Thermal expansion properties for these alloys are generally controlled by adjusting the nickel content or, to a limited extent, by variations in mechanical working and heat treatment. The inflection temperature increases with nickel content so that, at the expense of an increase in minimum expansivity, a wider temperature range of low expansion is secured in alloys containing 42 to 50% nickel.

Practical experience shows that four Ni-Fe compositions with quite different combinations of inflection temperature and expansivity will cover most situations: 36% nickel for low expansivity up to about 400 F, 42% nickel for temperatures up to about 650 F, 46% nickel for temperatures up to about 750 F, and 50% nickel for environments reaching 1000 F.

Cobalt can replace some of the nickel in the low-expansion alloys where high Curie temperature is desired. Although this technique has been used to some extent to produce alloys of the Invar type with extremely low or even negative expansivity in the room-temperature region, probably the most widely used is



2 Inflection temperature . . .
limits useful temperature range for low-expansion nickel-iron alloys, but can be adjusted by changing nickel content.



3 Curie temperature . . .
goes up with higher nickel content in iron low-expansion alloys, but this also increases minimum expansivity—often forcing compromise in design.

Kovar with 17% cobalt and 29% nickel. This alloy has largely replaced tungsten for sealing to Pyrex and similar low-expansion glasses. With vitreous enamels, especially where temperature cycling is a factor (as in wire-wound resistors) a 46% nickel-iron provides a good coefficient match.

Chromium improves the corrosion resistance of low-expansion alloys. For example—iron with about 57% cobalt and 9% chromium is useful in corrosive environments, especially as the low-expansion component in thermostatic bimetals. Another iron alloy, with 42% cobalt and 6% chromium, provides a good wetting surface for soft glasses in hermetic seals.

At higher chromium levels, the ferritic chromium stainless steels such as AISI 400 series have expansivities slightly below those of the plain-carbon and low-alloy steels. Certain alloys in the 400 series, free from abrupt changes in expansivity, can be sealed to soft glass and are used in metal television picture tubes.

HIGH-EXPANSION ALLOYS

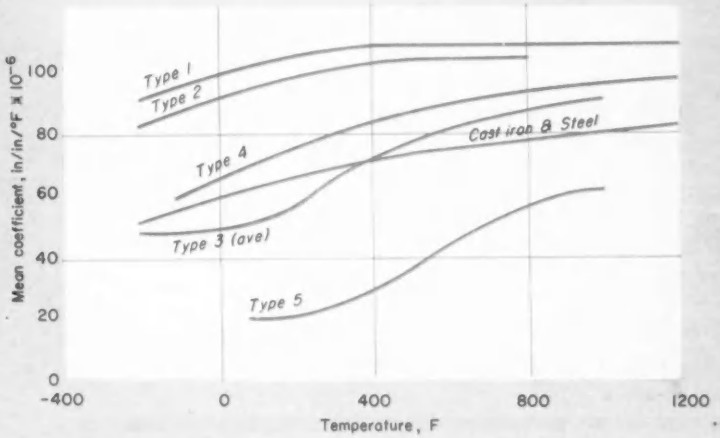
Straight carbon steel can be considered a boundary metal between the "low" and the "high" expansion alloy groups. However, higher coefficients of expansion are often desired. Widely used here, especially if high strength or special corrosion resistance is required, are nonmagnetic alloys or those nickel alloys that are weakly magnetic. When only a moderate increase over steel is needed, Inconel is often employed. Monel and related nickel-copper alloys constitute a family of slightly higher expansivities. Another family, with still higher values, are the nickel-chromium and nickel-manganese-chromium austenitic stainless steels of the AISI 200 and 300 series, with room-temperature expansivities in the range of 8 to 10 millionths per degree F. These alloys have generally excellent corrosion resistance and mechanical properties.

Expansivities above 12 millionths per degree F are obtained commercially by properly choosing the nickel, manganese, chromium and carbon content of the nonmagnetic austenitic steels. Typical uses for these alloys are in high-strength bolts for use with nonferrous parts and as control cables in aluminum air frames. The highest expansivities are usually found in alloys of lower nickel and chromium content. Consequently, maximum expansivity, rather than corrosion resistance, is the main factor in choosing these alloys—particularly for bimetallic elements.

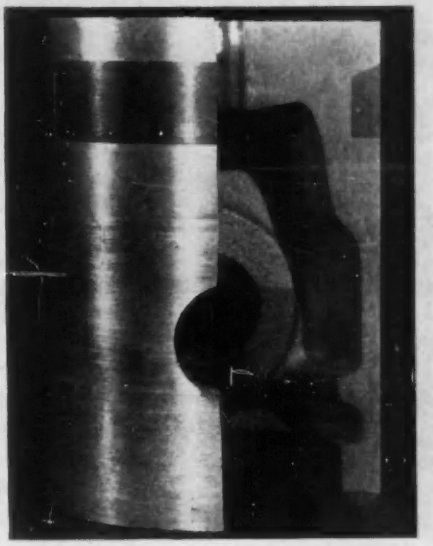
NICKEL CAST IRONS

When manufacturing economy and wear resistance are vital factors in thermal expansion applications—hot oil pumps, valves, and engine cylinder liners, for example—the high-nickel and nickel-copper cast irons can be used. This family, called Ni-Resists, are generally analogous to the controlled-expansion wrought nickel-irons, and provide room-temperature expansivities controllable between the limits of about 2 to 10 millionths per degree F. By treatment of the molten metal with magnesium, many of these alloys can be produced in ductile form with spheroidal, rather than flake graphite, to provide increased strength and toughness.

For minimum dimensional variation with changing



4 Nickel cast-irons . . .
can be matched to other structural metals. Here, mean coefficients (from 70F to indicated temperature) of several types are compared to cast iron and steel.



5 Aluminum pistons . . .
for caterpillar tractor carries cast-in-place insert of high-nickel cast iron for machining piston-ring grooves. Nickel alloy must match expansivity of aluminum, and be tough enough to retain rings.

temperatures and resistance to cracking by thermal shock, the low expansivity of the 36% nickel Ni-Resist Type 5 is useful. However, for matching the expansion coefficients of other alloys, Ni-Resist types with higher expansivities are employed. For example, the 30% nickel Ni-Resist Type 3 comes closest to matching the expansion curve for ordinary steel between room temperature and 500 F, and has been used to line the steel body of hot oil pumps for service up to this temperature. The 15% nickel Ni-Resist Type 1 matches closely the high expansivity of aluminum alloys (about 13 x 10^{-6}), and is used for cast-in-place ring-groove inserts in large diesel engines.

BIMETALS

Several of the foregoing alloys find use as the low-expansion side of bimetal thermostatic strip. One common thermostatic bimetal, a combination of Invar and brass, gives high activity but is somewhat limited in working-temperature range. Invar combined with Monel (a nickel-copper alloy) as the high-expansion side element can be used at higher temperatures. Occasionally, two nickel-irons with different Curie temperatures are combined to give a special shape to the deflection curve. Nickel-irons with cobalt and chromium additions improve corrosion resistance of bimetallic elements, and these alloys consequently often appear in appliance thermostats.

GLASS-METAL SEALS

In addition to Kovar, several other low-expansion alloys have been widely used for sealing to glass. Platinum was the standard material for glass-metal seals up to about 1911 when the demand for incandescent lamps grew so large a substitute had to be found. The answer proved to be a copper-clad 42% nickel-iron wire called Dumet, used in lamps and electron tubes to this day.

In glass-metal seals the expansion curve of the glass and the alloy must match closely below the softening temperature of the glass. It is not sufficient that the total expansion from room temperature to the softening point be the same for both materials, as substantial differences at intermediate temperatures may cause the glass to crack and separate from the metal. In addition, a good, bubble-free bond must be formed. Chromium additions promote the formation of an oxide film which facilitates good bonding.

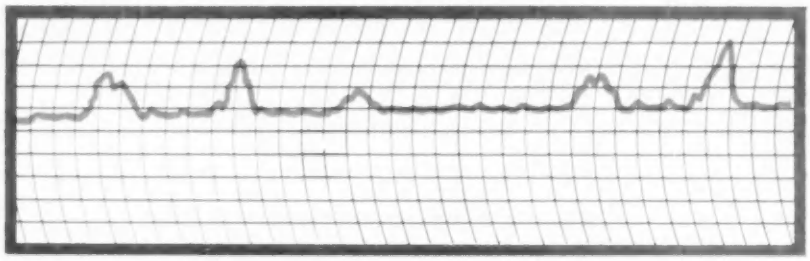
EDITOR'S NOTE: Current thermal expansion problems are discussed in two significant recent articles:
"Thermal Stress Fatigue," June '57, p 175, answers five basic questions on premature failures that often occur at high operating temperatures.
"High-temperature Fasteners," Sept. 30 '57, p 79, guides material selection for bolted structures up to 1300 F, with test results on locknuts covering stress rupture, relaxation and re-usability.

More on Nickel Alloys
Look for an article coming soon on the dimensional stability of Invar. It will show how to handle 36% nickel-iron for supercriticial dimension control.

How to DESIGN BALL BEARINGS for WATER LUBRICATION

Corrosion is one common problem, and there are others. Here are recommended materials for bearings, and tips on getting best performance

PHILLIP R. EKLUND
Westinghouse Electric Corp.



Erratic torque variations . . .
caused by presence of corrosion products characterize commercial bearings operated with water as the lubricant. This record, for a 3½-in. bearing, shows peak torques of 8 to 10 ft lb.

When leakage of lubricant from a ball bearing might contaminate a fluid, and seals are not completely effective—as in a pressurized-water reactor—water lubrication is about the only answer. Commercial ball bearings in water under 1000-psi pressure and at 200 to 300 F quickly develop erratic and "bumpy" friction with peaks that may become high enough to cause stall. Corrosion sets in quickly, leading to seizing, galling and severe wear even under light loads.

In comparison with general practice, loads and speeds are low. For example, a 3-in. ID main thrust bearing of a control rod drive carries a load of 150 to 250 lb at a normal speed of 11 rpm, although speeds may go up to 40 rpm under emergency conditions. Motor torque is in the range of 8 to 10 ft-lb, and bearing torque must be well under this value.

Bearing torque is the primary measure of performance in this application; accumulated wear and corrosion products contribute to excessive torque values. Early tests on commercial thrust bearings showed peak torques in the range of 15 to 25 ft-lb. Improved bearing designs reduced peak values to 3 to 4 ft-lb over test periods running from 200,000 to 1,250,000 rev; average running torque seldom exceeded 2 in.-lb.

Major changes in bearing design responsible for this increased life were the use of cobalt-base alloys for balls and races, a loose fit, and larger balls with closer-matched diameter. Substantial improvement was also obtained by adding to the water a trace amount of polyalkylene glucol, a compatible material with some lubricating properties. Addition of only 0.2% reduced wear by 15:1 on a 3-in. ID bearing under 52-lb load at 130 rpm.

Failures with commercial bearings were not the result of usual spalling induced by fatigue. Rather, the problem was abrasive wear caused by corrosion products, and the possible effect of water entrapment in the contact areas.

BEARING MATERIALS

First requirement for a water-lubricated bearing is resistance to water corrosion. Commercial bearing materials corrode badly, and some other materials con-

Cobalt-base Bearing Materials

Application	Composition Co	Cr	W	Hardness R_c	Crushing Load*
Races	52	31	10	52	11,300
Races, balls	50	20	15	52	
Balls	50	28	20	58	8,100
Balls	46	31	13	55	8,700
Balls	41	32	17	58	8,000

*For ½-in.-dia balls; center one of three balls loaded axially

sidered corrosion resistant were also found unacceptable. Bearing materials must also be wear resistant and free from galling or seizure. This narrows the field to cobalt-base alloys or hardenable stainless steels.

A number of alloys were tested as races and balls. Tungsten carbide had high hardness but the cobalt binder leached out in the hot oxygenated water. Chromium carbides appear promising but further study is needed. The type 440 C stainless used in food equipment proved marginal but a modified composition with 4% molybdenum shows some promise.

The most satisfactory race material for non-shock service is the cast 52% cobalt alloy—table on facing page. For shock loads the wrought 58% is best. The most suitable ball material for both shock and steady loads is the cast 46% cobalt alloy.

To reduce material and machining costs the wrought 46% cobalt alloy was used as a hard facing for the groove area in a race made from type 304 stainless. A $\frac{1}{16}$-in. hard facing deposited by acetylene torch gave satisfactory results for steady loads, but the base material was too soft for impact loads. A better combination for shock service is expected with hard-surfaced races made from type 410 stainless heat-treated to R_c 30 to 40; this is now under development.

While retainer design was felt to be a contributing factor this could not be confirmed. One bearing was designed with no retainer, but later work led to a retainer made from 17-4 PH that had no effect on bearing performance. Retainers were made in halves, heat-treated to R_c 40 to 45, and assembled with type 314 stainless rivets between ball pockets. Equally satisfactory were retainers made from type 400 and 416 stainless.

MECHANICAL REQUIREMENTS

Peaks in torque arise from accumulation of corrosion and wear products in the races. Water-lubricated bearings therefore must run "loose" by commercial standards. Thrust bearings have 0.003 to 0.004 in. radial play, which is also an advantage in accepting misalignment.

Contact stress must be kept low by using a high ratio of ball diameter to groove diameter. Bearings currently in service have a ratio of 53% at the inner race and 56% at the outer. Bearings with calculated (Hertz) contact stress no higher than 100,000 psi give peak torques of 4 ft-lb or less.

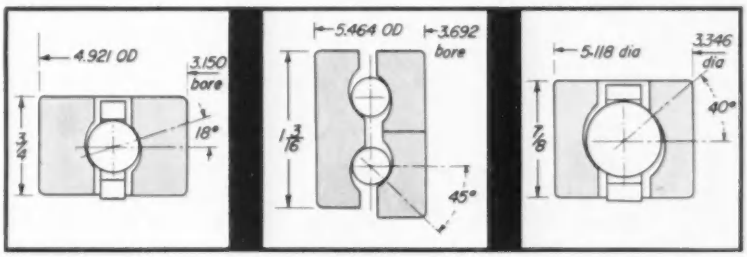
Because of the absence of cushioning contributed by an oil film, maximum variations in ball diameter were held to 0.00001 in. for all balls in a bearing. ABEC class 5 tolerances were adopted for parallelism and shoulder squareness for the groove on the inner race.

Commercial bearings are made with a surface finish of 8 microinch. The best torque performance for a water lubricated bearing was obtained with the inner race machined with a formed carbide tool to an 11-microinch finish.

To obtain more clearance, a 45° contact angle and 0.003-in. radial play was considered, although the cost was higher. The same advantages were later obtained from a single-row bearing with a non-circular groove; in addition, the axial play was independent of radial play and contact angle.

EDITOR'S NOTE: Article is based on a paper presented by the author at ASLE, Detroit, April 15, 1957. For a discussion of problems in using water lubrication for sliding surfaces, see "Water Lubricated Bearings," Sept 30 '57, p 74.

DEVELOPMENT OF BEARING DESIGN FOR WATER LUBRICATION



Conventional design . . . with corrosion-resistant balls, races and retainer, and large axial play.

Elimination of retainer . . . had no significant effect on performance but double-row design did increase the cost.

Noncircular groove . . . combined with larger ball dia gave longer life and lower peak torque.

Diagram	A	B	C
Races	50 Co-20 Cr	50 Cr 20 Cr	50 Cr 20 Cr
Balls	50 Co-20 Cr	46 Co 31 Cr	46 Co 31 Cr
Retainer	17-4 PH	None	17-4 PH
Ball dia, in.	½	½	⅝
Radial play	0.004 in.	0.003 in.	0.003 in.
Axial play	0.026 in.	0.003 in.	0.008 in.

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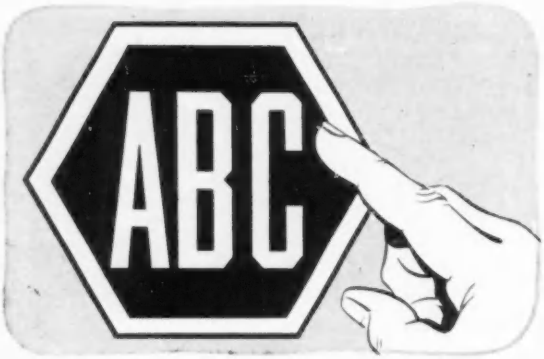

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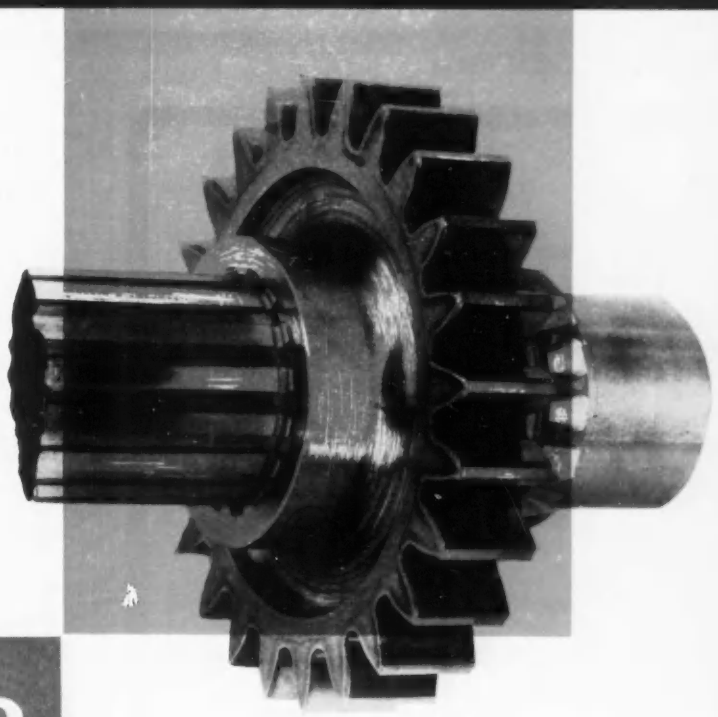
- Fixed or flexible
- Size and face width
- How many teeth
- Pressure angle and tooth height
- Industrial practices and standards



how to design INVOLUTE SPLINES

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Mr. Dudley, who has charge of gear and spline development in GE's Medium Steam Turbine Dept., is well known for his reference text, *Practical Gear Design*, published by McGraw-Hill Book Co. This article includes design data not previously published.

Trend in splines today is toward an involute profile similar to gear teeth. Main functions of a spline are to transfer torque from a shaft to gears, pulleys, fans, etc., or to couple two shafts together. Some components are loosely fitted, others solidly shrunk on and removable only with difficulty.

A spline coupling with involute teeth will transmit more torque for its size than any other type, with almost no speed limitations. For example, turbine shafts at 10,000 rpm or more, carrying several thousand horsepower, can be readily connected to a driven machine by a gear-tooth coupling; few other types of couplings can do it.

But perhaps the most important reasons for widespread use of involute splines is that they can be cut and measured on the same machines that cut and measure gear teeth, and most shops have gear-cutting facilities.

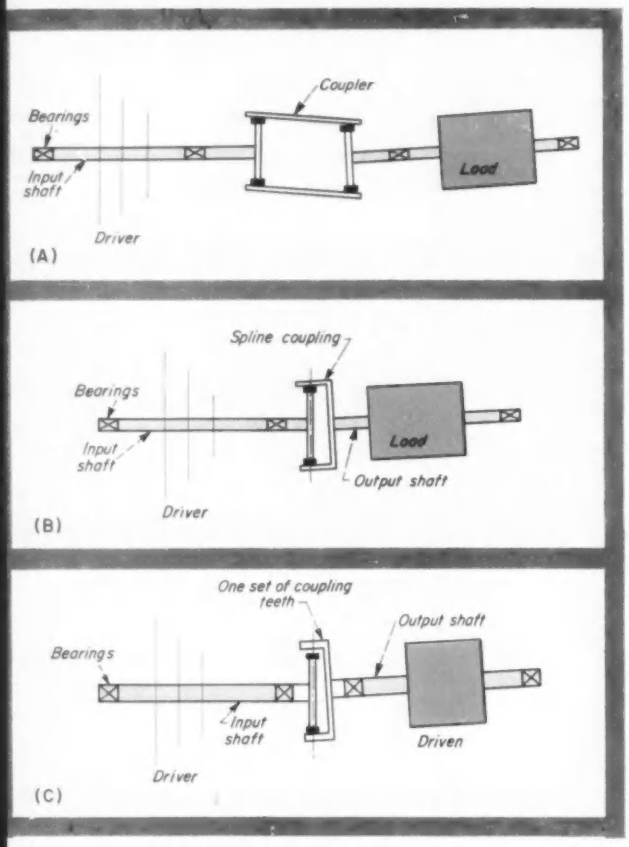
Splines differ from gears, however. The spline has no rolling action, and all teeth contact at once. Splines seldom pit or break at the root, although they do fail by fretting corrosion and by fatigue.

FIXED OR FLEXIBLE SPLINES

Fixed splines permit no relative or rocking motion between internal and external teeth, and can be either shrink fitted or loosely fitted together. A loose fit may be subject to backlash between gear and shaft when not under torque; but once under torque, the spline will center itself, take a fixed axial position, and axes of the mating splines will become coaxial.

Flexible splines permit some rocking motion, and under torque the teeth slip axially to accommodate axial expansion or runout. The axes of the mating splines usually intersect instead of being coincident. Although the angle between the axes is small, normally much less than a degree as the coupling rotates, angular misalignment will cause some rocking every revolution. Misalignment plus axial movement may cause continuous relative movement at the spline tooth.

Application, rather than tooth design, determines whether a spline is fixed or flexible. Tooth form will



Controlling misalignment . . .
when using splined couplings. Double-spline system (A) accommodates both angular misalignment and offset. Although shown here with internal teeth, coupler usually is designed with internal teeth. Single-spline system (B) accepts only mis-alignment but uses fewer parts (note three bearings instead of four). Four-bearing, single-spline system (C) may function as an internal gear system if not aligned correctly.

not stop a flexible coupling from attempting to flex, and if the application does not want to flex, loose-fitting teeth probably will cause not flexing. However, for good design, teeth for a flexible coupling should be designed to permit flexing, and a fixed coupling should be designed to discourage flexing.

Fixed splines usually are mounted by shrinking the gear on the spline or fitting a ring at each end. The rings center the gear and allow the spline to transmit torque only.

Axial and angular misalignment when a motor is coupled to a load can be compensated for by using a double-spline system, (A) in the accompanying diagram, with the teeth of the coupling subject only to angular misalignment. Shaft offset is converted by the coupler, or "distance piece," into an angular misalignment. Increasing the coupler length will decrease misalignment.

The three-bearing system (B) accepts only angular misalignment—the two shafts must intersect at the coupling for it to operate correctly. Also, because the output shaft has only one bearing, the coupling will carry a heavier load.

Trouble will arise if four bearings are mounted with only one spline, as in (C). With only a slight amount of misalignment the spline functions as an epicyclic gear system. The load is concentrated on only a few teeth, overloading the tooth surfaces as much as 10 to 20 times. In addition, the reaction places a serious load on the bearings. However, this system can function correctly if the shafts are limber and bend to intersect at the coupling center.

HOW TO ESTIMATE SPLINE SIZE

First step in designing a spline is to make a preliminary estimate of the size required, using chart, opposite page, relating spline capacity to pitch dia for seven types of service. The chart is based on a study of spline performance and indicates the normal range of torque for flexible couplings and for fixed splines.

Average commercial practice is represented at (A) with involute teeth of 20° or 25° pressure angle, and tooth depth about 75% of full-depth gear teeth. Teeth are of low-hardness steel and finished by cutting. Face width is $\frac{1}{4}$ to $\frac{1}{3}$ of the pitch dia. Misalignment is generally less than 0.003 in. per in.

High-capacity couplings (B) have tooth design similar to (A), but the face width may be wider, from $\frac{1}{4}$ to $\frac{3}{4}$ of the pitch dia. Misalignment may be held as low as 0.001 in. per in. Material is usually alloy steel hardened to R_c 55.

Aircraft flexible couplings (C) have a 30° pressure angle and hardnesses ratings in the range of R_c 55 to 65. Tooth proportions range from the 50%-depth proportions of the ASA B5:15-1950 spline standard to as high as 67%.

Aircraft splines with 1.250 in. and smaller pitch dia generally have face width equal to or greater than the pitch dia. On larger dia, flexible splines face width is narrower, $\frac{1}{4}$ to $\frac{3}{4}$ the pitch dia. It is debatable whether the wide faces of splines below 1 in. dia actually increase load capacity.

By coincidence, this rating is typical of a single key used as a fixed coupling. When used for single keys, the length is 1 to $1\frac{1}{4}$ times the shaft dia. Stress in the shaft is about 7,500 psi, neglecting stress concentration at the keyway.

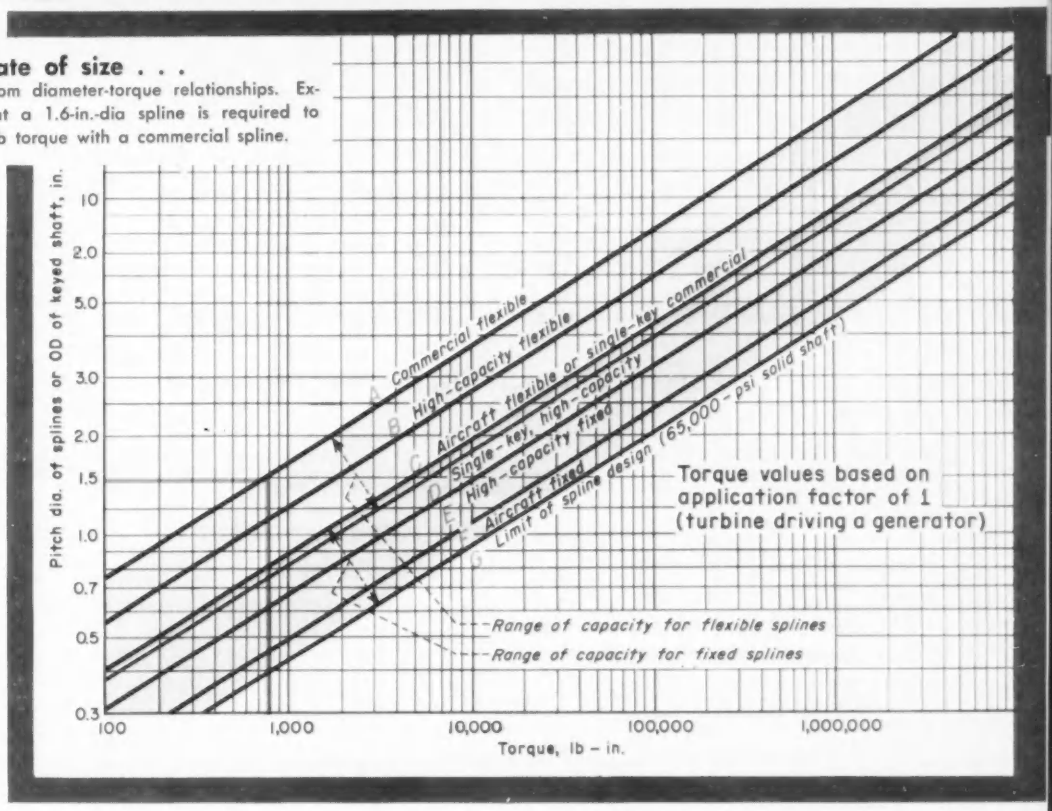
High-capacity single keys (D) set up 9,500-psi stress in the shaft away from the keyway. Length and size of key is the same as for (C). Shafts and keys are made of heat-treated steel of moderately high hardness. Design is typical of commercial flexible couplings keyed to motor or generator shaft extensions.

Multiple-key fixed spline (E) has involute teeth with pressure angles from $14\frac{1}{2}$° to 45°; tooth depth is usually 50% or less. Length of spline generally ranges from 75% to 125% of the pitch dia. Shaft hardness is BHN 200 to 300.

High-capacity aircraft splines (F) will have spline length from 50% to 100% of pitch dia. Shafts are generally hollow to save weight, and hardness ranges up to R_c 58 for case-hardened parts.

Boundary line of spline design practice (G) is for a solid shaft with 65,000-psi shear stress. For a hollow

Quick estimate of size . . .
can be made from diameter-torque relationships. Example shows that a 1.6-in.-dia spline is required to transmit 800 in.-lb torque with a commercial spline.



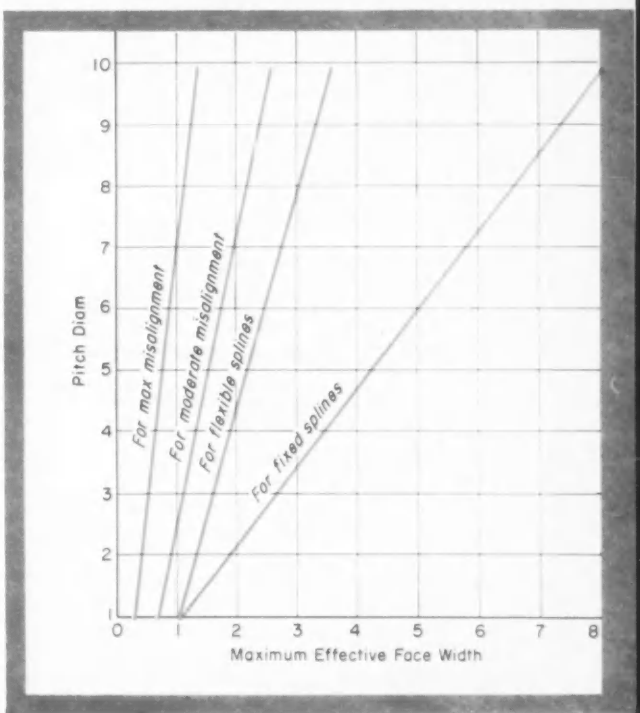
shaft with a bore 75% of the outside dia, shear stress would be 95,000 psi. Such splines can be built to work. Several years ago, the author designed a fixed aircraft spline 1.860 in. dia and tested several models to destruction. The spline took an appreciable permanent set at 100,000 lb-in. of torque, and ruptured at about 160,000 lb-in. The steel was 35 R_c and a helix correction was used. From the chart the torque rating is 75,000 lb-in. at 1.860 in.

HOW WIDE THE FACE

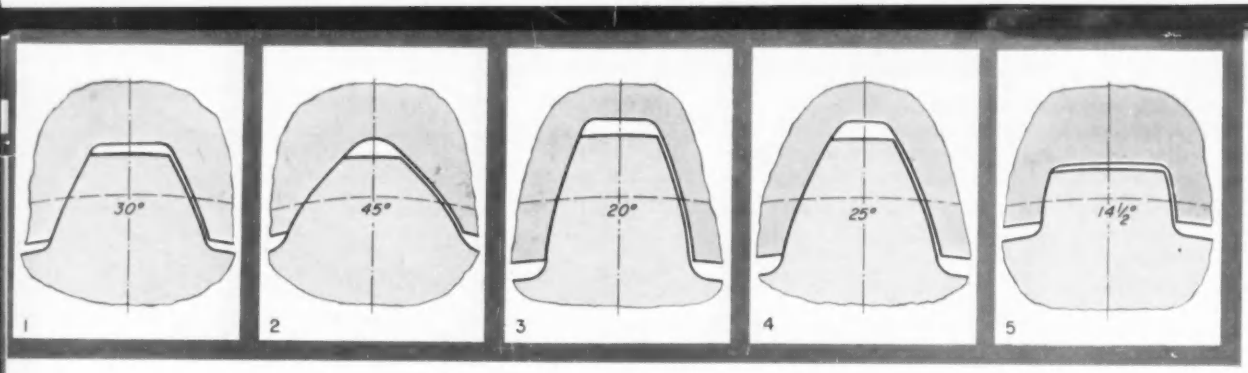
For fixed splines with width $\frac{1}{4}$ the pitch dia, the teeth have same shear strength as the shaft—providing they are spaced accurately so that all are loaded uniformly. Since there is always some error in tooth spacing, the face width should be at last $\frac{1}{3}$ of the pitch dia, which will balance tooth and shaft strength with only half the teeth working. If weight is not too important, it is good design to keep the face width equal to the pitch dia.

In flexible splines, a wide face width often contributes little or nothing to load-carrying capacity even though conventional design formulas indicate otherwise. Unfortunately, there is neither good theory nor test data on just how much face width is useful. Flexible splines are generally misaligned since the accomodation of misalignment is one of the main functions. The spline teeth are so stiff that they have practically no deflection, and most of the load will fall on the ends of misaligned spline teeth. A wide face width will not relieve the intensity of end loading but will extend the time required for the wear in the middle of the spline to catch up with wear at the ends.

Maximum effective width can be estimated from



Maximum face width . . .
for fixed and flexible splines. Wide face widths in splines often contribute little to load-carrying capacity.



Five common spline tooth forms

TABLE I—SPLINE TOOTH PROPORTIONS

for 1 Diametral Pitch

Tooth Form No.		1*	2*	3	4	5
ASA Standard No.		B5.15–1950	B5.26–1950	.....	.....	.....
Pressure Angle		30°	45°	20°	25°	14½°
Nominal Depth (Compared to Gear Teeth)		50%	40%	75%	70%	30%
Addendum of External, a_e	Side-bearing fit	0.409	0.500	0.750	0.700	0.340
	Major-dia fit	0.500	.....	0.950	0.900	0.430
Dedendum of External, b_e	Normal design (flat root)	0.600	.....	1.000	0.950	0.390
	Full dedendum (fillet root)	0.900	0.500	1.250	1.050	.....
Addendum of Internal, a_i		0.500	0.300	0.750	0.700	0.250
Dedendum of Internal, b_i	Side-bearing fit (flat root)	0.500	.....	0.950	0.900	0.430
	Major-dia fit (flat root)	0.500	.....	0.950	0.900	0.430
	Full dedendum (fillet root)	0.900	0.700	.....	.....	.....
Chamfer on External Tip for Major-dia fit	Minimum height chamfer	0.091	.....	0.200	0.200	0.090
	Slope of chamfer, β	55°	.....	50°	50°	45°
Fillet on Internal for Major-dia Fit	Maximum radial height	0.085	.....	0.200	0.200	0.090
	Approximate radius, R_i	0.160	.....	0.200	0.225	0.075
Radius at Root of External Tooth, R_e	Normal dedendum, min. rad.	0.075	.....	0.200	0.225	0.100
	Full dedendum, min. rad.	0.250	0.350	0.250	0.250	.....
Minimum No. Teeth with Addendum Adjustment		.....	.....	18	10	10
Minimum No. Teeth without Addendum Adjustment		6	6	26	16	16
Nominal Contacting Depth, h	Side-bearing fit	0.900	0.800	1.500	1.400	0.590
	Major-dia fit	0.900	.....	1.500	1.400	0.590
Effective Space Thickness of Internal, S		1.571	1.771	1.600	1.600	1.625

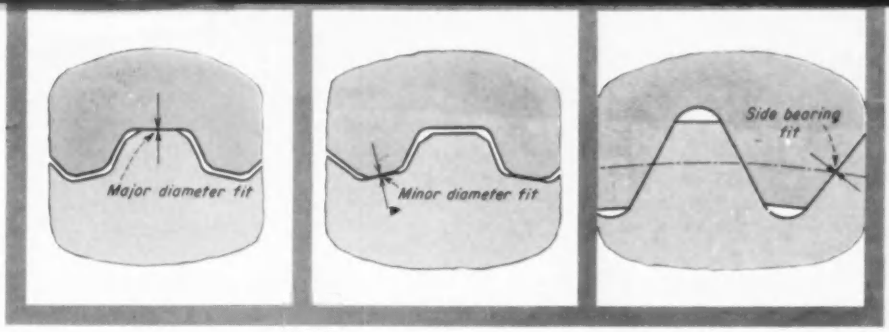
* Based on the author's interpretations of the ASA standards covering these forms. Standard B 5.15–1950 is under process of revision.

TABLE II—TYPICAL FIXED-SPLINE CALCULATION

1. No. of Teeth, $N = 16$
2. Diametral Pitch, $P_d = 10$
3. Working Depth, h = Table $I/P_d = 0.059$
4. Pitch Dia, $D = N/P = 1.600$
5. Pressure Angle, $\phi = 14° 30'$
6. Fit = major dia

		EXTERNAL	INTERNAL
7.	Addendum	a_e = Table $I/P_d = 0.043$	a_i = Table $I/P_d = 0.025$
8.	Dedendum	b_e = Table $I/P_d = 0.039$	b_i = Table $I/P_d = 0.043$
9.	Major Dia	$D_e = D + 2a_e = 1.6870–1.6875$	$D_{ri} = D + 2b_i = 1.6860–1.6867$
10.	Minor Dia	$D_{re} = D - 2b_e = 1.526–1.516$	$D_i = D - 2a_i = 1.550–1.552$
11.	Thickness, effective	$t_e = 0.1620–0.1605$	s_e = Table $I/P_d = 0.1625–0.1640$
12.	Thickness, actual	$t = 0.160–0.159$	$s = 0.164–0.165$
12.	Face Width	$F = 1\frac{5}{8}$	$F = 1\frac{1}{2}$
14.	Form Dia	$D_{fe} = D - (2b_i + \Delta h) = 1.550$	$D_{fi} = D_i + (2h + \Delta h) = 1.670$
15.	Tip Chamfer, slope	β_e = (Table I) = 45°	.....
16.	height	H_t = Table $I/P_d = 0.009–0.015$	.....
17.	Root fillet, radius	R_e = Table $I/P_d = 0.010–0.015$	R_i = Table $I/P_d = 0.007$
18.	height	$H_e = 0.009$ max	H_i = Table $I/P_d = 0.009–0.003$

△h is allowance for 'extra' involute. It may vary from 0 to 0.050/P_d.



INVOLUTE SPLINES

Three types of spline fits

the accompanying curve. While these values could be exceeded, the effective width should be used in calculating design stresses. Also, for fixed splines without helix modification, the effective width should not exceed:

$$F_e = 5{,}000\ D^{2.5}/T$$

where F_e is the maximum effective face width, D the pitch dia, in., and T is torque, lb-in.

SPLINE TOOTH FORMS

The five involute tooth forms shown on opposite page are the most common in use today.

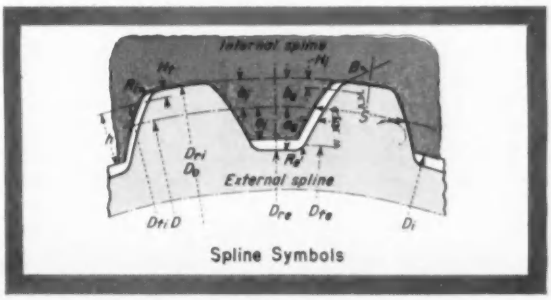
Form 1 is a standard spline tooth sponsored by ASME, SAE, AGMA and NMTBA, and covered by ASA B5: 15-1950 (currently under revision by the SAE Parts and Fittings Committee.) The form is a stub tooth having about 50% the working depth of a standard involute gear tooth. It is relatively easy to manufacture, has a 30° pressure angle, and can be made with as few as six teeth.

Form 2 has a 45° pressure angle with about 50% depth. It is used for fine-pitch involute "serrations." Coarsest pitch shown in the ASA standard is 10 pitch, but it can be produced with as few as six teeth. It is often employed with relatively large numbers of teeth to get many index positions in attaching parts, because it gives maximum shaft tooth dia and adds to the shaft strength of externally toothed parts.

Form 3 has a 20° pressure angle, a 75% depth, and is similar to stub-gear teeth. This type, but with 50% depth, is used in automotive applications. It has 50% more bearing area than Form 1 or 2, and enough depth to shave easily while the first two forms are not suitable for shaving.

Form 4 has a 25° pressure angle and 70% depth. This form has enough involute to shave well, and 40% more tooth-bearing area than either of the first two forms. It has a stronger centering action than Form 3, but not as strong as Form 1 or 2. Larger-dia marine couplings use this shape.

Form 5 has only 30% depth, and 14½° pressure angle. This tooth cannot be shaved and does not have much centering tendency. It is a poor choice for a flexible coupling, but has some advantages as a fixed coupling where there is no relative motion between the tooth surfaces. The shallow depth permits a larger shaft than for the other forms, and for fixed splines the shaft is often the limiting factor in torque capacity. The low pressure angle develops less bursting stress in the internally tooth member; wall thickness can be reduced. The form also has the largest land at the top of the external tooth. It is a good choice for a fixed spline—particularly with a major-dia fit.



SPLINE DESIGN DATA

Three types of spline fits are: major dia, side bearing, and minor dia. In the major-dia fit, outside dia of the external tooth is closely fitted to root dia of the internal tooth, so addendum of the external equals dedendum of the internal. It is best to leave a small fillet at the root of the internal tooth and to chamfer the external tooth to clear this fillet. With cold-formed (rolled) external splines, the mating internal teeth can be cut with a broach to eliminate the usual internal fillet.

The side-bearing fit has the tooth thickness of the external almost equal the space width of the internal. Addendum of the external is short enough so it will not hit the root fillet of the internal. No chamfer or radius is used on the tip of the external.

The minor-dia fit spline is a fit at the root of the external. Here the dedendum of the external equals the addendum of the internal.

DESIGN TOLERANCES

Of the three, the major-dia fit is easiest to control. The outside dia of the external can be precision-ground to a tolerance of 0.0005 in. or less. On internal parts smaller than 2 in. dia, the root dia can be broached to a tolerance of 0.001 in. or less. This makes it possible to hold a tolerance range as low as 0.0015 in. For a press fit, the interference might be selected to range between 0.0005 and 0.002 in.

If the fit is made on tooth thickness, the teeth can be held to 0.0015 in. or less. However, further tooth tolerance (total index error, profile and alignment) have a composite effect which, even on small splines, can be as much as 0.005 in.

If a close fit is needed for centering purposes, the major-dia fit gives better results than the side-bearing fit. However, the latter controls backlash and is desirable in slow-speed applications where close centering is not required.

The minor-dia fit is seldom used. Its only advantage is that root dia of the external spline is formed by the same operations as the sides of the teeth. This tends

to guarantee that the root dia will be concentric with tooth sides.

Spline-tooth proportions for 1 DP are shown in Table I; Table II illustrates the typical computations for a 16-tooth spline with a press fit on the major dia.

Where a major-dia fit or a centering-ring fit is used, there is no need to be too close on clearance. In this case, clearance allowance similar to those used in gears are used, Table III. These values are appropriate for flexible coupling designs—provided an extreme amount of misalignment is not contemplated.

HOW MANY TEETH

Cost and manufacturing considerations determine the number of teeth because, contrary to gear design, doubling the number of spline teeth has no appreciable effect on tooth stress. The teeth become half as big when doubled, but there are twice as many to carry the load—the two effects tend to cancel each other.

Even-number teeth should be used wherever possible. An odd number puts a tooth opposite a space, which makes it impossible to directly measure root, bore and outside dia. Also, odd numbers of spline teeth are a nuisance to manufacture, and contribute nothing to load-carrying capacity. Recommended minimum numbers of spline teeth are shown in Table IV; employ a larger number to obtain a larger root dia on the external, to make an easier tool design, or to improve lubrication. Generally, however, the cost goes up.

INDUSTRY PRACTICES

In each industry, interchangeability of parts, customer acceptance, and industry standards establish almost mandatory practices for spline design.

In the aircraft field, an engine may have a dozen flexibly splined accessory drives, handling torque from 10 to 6,000 in.-lb. Fixed splines mount the propeller and couple the reduction gear and the engine. Generally, splines to drive accessories are specified by AND standards (see Table V). Pitch is listed as a fraction; a 20/40 pitch has a 20 diametral pitch with a stubbed-tooth height approximately equal to a 40-pitch standard full-depth gear tooth. This method does not give the exact addendum and dedendum, and is more of a hazard than a convenience.

Some designs in the table are stubbed to one-half full height while others to only two-thirds. The two-thirds height carries more load and resists wear better, but the one-half height agrees with the ASA standard.

Many designers are standardizing on Form 1 teeth; almost all avoid the keyed-on gear-tooth couplings used in commercial machinery.

Automotive splines in general have changed over from straight-sided to involute splines; transmission splines for gear shifting have the external member finished by shaving, and the internal member finished by hard broaching or lapping. For shaved splines, Form 3 with a 50% depth is favored.

Rolled splines need a high pressure angle, shallow depth and a radius root fillet. Forms 1 and 2 are preferred with a full dedendum on the external.

Automotive splines for shift gears are designed for a clearance C from about 0.0015 to 0.0045 in. Close-fit non-shifting splines with a side fit for centering are designed for 0 to 0.0030 in. clearance. Interference for press fit is about −0.0000 to −0.0020 in. For finer pitches, 10 to 24 P, clearance is reduced by 0.001 in.

In industrial machines, where cost is usually more important than weight and space, standard motors and speed reducers are used. A complete drive can be assembled on a common base with two standard spline couplings. Teeth are not as hard or as accurate as used in aircraft; Form 3 is the most popular. Catalog spline couplings are standardized by manufacturers and produced in quantity. They are not balanced for high speeds unless made to order.

TABLE III—SUGGESTED SPLINE CLEARANCES

Diametral Pitch	Clearance C, in.
1	0.024–0.036
2	0.020–0.030
3	0.016–0.020
4	0.012–0.026
6	0.010–0.018
10	0.008–0.014
14	0.006–0.012
20	0.004–0.008

Coming soon

A second article by Mr. Dudley will analyze stresses in splines, load ratings, wear, types of failures, lubrication and spline-manufacturing methods.

TABLE IV—RECOMMENDED MINIMUM NUMBERS OF SPLINE TEETH

Pitch Dia	Broaching			Shaping				Shaving or Grinding	
Angle	30°	20° or 14½°		30°	25°	20°	14½°	25°	20°
Depth	50%	50%	30%	50%	70%	75%	30%	70%	75%
0.3	6	10	10	12	18	..	..	..	..
0.8	8	12	10	14	20	22	16	..	..
1.0	8	12	10	16	20	24	16	..	..
2.0	8	12	12	20	20	24	24	..	..
4.0	10	16	16	24	24	32	24	48	48
8.0	20	20	24	32	32	40	32	56	56
12.0	30	30	36	36	36	48	36	60	60

TABLE V—AIRCRAFT ACCESSORY SPLINE STANDARDS

Military Spec.	Type	Pitch Dia	No. Teeth	Pitch	Min Face Width*	Torque, lb-in.* Max	Torque, lb-in.* Continuous
AND 20001	INT.	0.600	12	20/40	0.937	2,200	500
AND 10260	EXT.	0.600	12	20/40	0.812		
AND 20002	INT.	0.800	16	20/30	1.562	2,700	600
AND 10262	EXT.	0.800	16	20/30	0.600		
AND 20002	INT.	1.200	24	20/30	1.438	11,000	2,500
AND 10262	EXT.	1.200	24	20/30	1.000	6,000	
AND 20007	INT.	1.625	26	16/32	1.063	18,500	4,200
AND 10266	EXT.	1.625	26	16/32	1.180		

* Typical values.

PLATED FINISHES

THE CHOICE WIDENS

Electroplated alloys offer coating properties that single-metal deposits cannot match. Here is a guide to useful applications of both types.

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Metal & Thermit Corp., New York City

ROBERT M. MacINTOSH, *Manager*
Tin Research Institute, Inc., Columbus, Ohio

Why Electroplate?

It's often an inexpensive way to achieve:

- **Corrosion resistance**
- **Abrasion resistance**
- **Solderability**
- **Dielectric properties at surface of metal parts**
- **Improved appearance, decorative detail**

Recent advances in electroplating have carried it beyond limitations imposed by conventional single-metal deposition. Through improved techniques and control methods, it is now easier to profit from the advantages of alloy plating–the codeposition of two or more metals at the same time. Such coatings provide combinations of properties that conventional single-metal depositions cannot provide. For example, alloy deposits are denser and harder, more corrosion resistant, brighter or more easily buffed, and more protective for the base metal.

The reference chart on the next two pages is a guide for selecting among 17 now-common metal coatings. Listed are their functions and properties, along with the base metals they can cover.

The five tin alloys described are examples of plate deposits now important because they have become

(continued on page 84)

Properties and Applications of

Plating Materials	Base Metals	Uses	Thickness, in.	Corrosion Resistance	Finish
Tin-copper (bronze)	Steel, brass, copper, zinc-base die castings	Decorative finish Reflectors Undercoat for Cr plate	On brass and copper: up to 0.0005 On steel: 0.001	Excellent	Bright or flat finish; flat finish can be polished
Tin-cadmium	Steel, brass, copper	Galvanic protection for iron and steel	0.00005 to 0.002	Better than cadmium in marine atmosphere	Silvery white
Tin-lead	Steel, brass, copper	Bearing metal Solderable coating	0.0002 and higher	Good	Resembles lead
Tin-Nickel	Most base metals	For corrosion resistance and low-friction surfaces	0.0005 to 0.002	Excellent	Resembles nickel, with rose tint
Tin-zinc	Most base metals	For corrosion resistance, solderability and abrasion resistance	For solderability: 0.00015 to 0.0003 For corrosion resistance: 0.0003 For abrasion resistance: 0.005 to 0.0007	Excellent; galvanic protection for iron and steel	Silvery white matte
Copper-zinc (brass)	Steel, aluminum, zinc, stainless steel (depassified)	Decorative finish To promote adhesion of rubber to base metal	Decorative: 0.0001 to 0.0005 Rubber adhesion: 0.00002 min	Low, unless lacquered	Yellow brass finish, or mirror-like on polished base metal
White brass	Steel, copper, yellow brass	For corrosion resistance	Usually 0.00025	Good	Bright
Cadmium	Steel, gray iron, brass, copper	Protection for marine and high-humidity atmospheres	0.00015 to 0.0003 or heavier	Galvanic protection Inferior to zinc in industrial atmospheres	Soft white luster
Chromium	Iron, steel, brass, zinc	Decorative appeal Tarnish and corrosion resistance Hardness for wear	Decorative: 0.00001 to 0.00002 Wear resistance: 0.001 to 0.005	Excellent, but corroded by halogen acids and sulfuric acid	Excellent appeal Mirror-like finish reproduces detail
Copper	Zinc, aluminum, brass, steel	Decorating other metals Undercoat for other plating to prevent case hardening in ferrous metals	Undercoat for nickel: 0.0001 to 0.0005 Zinc: Minimum of 0.0002	Poor	Excellent when polished Lacquered to prevent corrosion
Gold	Copper, brass, nickel, silver	Jewelry, musical instruments Laboratory and electronic equipment (solderability and electrical characteristics)	0.000002 to 0.001	Very high, especially at elevated temperatures	Excellent, used mostly for this feature
Lead	Iron, steel, copper	Corrosion protection against cold halogen acids and sulfuric acid	Atmospheric exposure: 0.0005 and higher Severe exposure: 0.005 to 0.05	Excellent for non-oxidizing acids Excellent for industrial atmospheres	Dull gray
Nickel	Steel, zinc, copper, brass, aluminum, magnesium alloys	Corrosion protection Building up worn parts Electroforming	Corrosion protection: 0.0012 on steel and zinc; 0.0005 on brass	Very good for alkalis Electropolishing improves resistance	Dull white to mirror finish; can be buffed
Rhodium	Copper, nickel, silver, palladium, platinum, gold, and alloys of these metals	Hard corrosion-resistant electric contacts Reflectors	Decorative: 0.000001 Electronic: up to 0.001	High with heavier deposits (0.0005)	Excellent; used in jewelry for appearance
Silver	Many metals, including iron, nickel, aluminum, copper or their alloys; glass and plastics	Decoration Electrical and chemical equipment Mechanical parts	Varies considerably with use	Highly resistant	Excellent
Tin	Iron, steel, brass, zinc, aluminum, copper, and their alloys	Cans Bearings Piston rings Solderable coatings	For solderability: 0.00015 For outdoor use: up to 0.001	Corroded by most acids Lacquer coats applied for corrosion resistance	Matte white can be brightened by heating
Zinc	Iron and steel	For corrosion resistance	0.0003 to 0.0005	Attacked by most acids and alkalis	Flat white or bright

Alloy and Single-metal Electroplates

Adhesion	Hardness	Abrasion Resistance	Ductility	Solderability	Reflectivity	Remarks
Excellent	Good, approximately same as nickel (325 VPN)	Good	Good in dull plate, less in bright plate	Fair	High on bright plate or buffed flat finish	Used extensively in bathroom fixtures, tableware
Satisfactory	Moderately soft	Good	Good	Fair	Low	Cost similar to that of cadmium plate
Good	Moderately soft	Poor	Good	Excellent	Poor, like lead	For soldering: 40% lead, 60% tin
Excellent	Excellent (about 625 Vickers)	Good	Moderate	Excellent	Good on polished surfaces, can be buffed	65% tin, 35% nickel Excellent throwing power
Good	Similar to tin	Good	Extremely good	Excellent	Low	78% tin, 22% zinc Solder base quickly applied Cheaper than cadmium plate
Excellent	Soft, easily scratched	Low	Good	Good with lead tin solders and rosin or acid fluxes	High	For rubber adhesion, copper content must be between 72 and 78%
Satisfactory	Harder than zinc	Like zinc	Fair	Not normally soldered	Develops insoluble corrosion products similar to zinc	Composition: 20% copper, 80% zinc
Satisfactory	Low	Less than zinc	Low; not used where ductility is important	Good	Medium luster only	Used on cast iron to improve zinc coverage
Excellent	Extremely hard	Extremely good but soft base metals may cause plate to crack	Very poor	Not normally soldered	Very high; depends upon polish of base metal	Highly resistant to wetting by oil
Excellent	Extremely soft	Poor	Very good	Fair if protected by lacquer	High when buffed	Coats of 0.0003 in. will improve bond to rubber Also used for electroforming
Excellent	Soft	Very low	High	Excellent	High	High cost limits use
Good	Very soft	Very low	Good	Should be alloyed with tin	Poor	Excellent base for paint
Good	Hard (up to 450 Vickers)	Depends upon hardness	Good for thin coats	Difficult	Very high on bright plate or buffed dull finish	
Satisfactory	Between nickel and chromium	Good	Limited	Fair	Extremely high, 78% of light is reflected	
Good, applied as a strike followed by plating	Relatively low	Good bearing properties	Good	Excellent after plating; poor shelf life	Very high	Many unusual properties
Good	Soft	Poor	Excellent	Excellent	High when heated	Resistant to tarnish Nontoxic
Good	Relatively soft	Less than chromium, nickel or tin	Very good	Soldering requires corrosive fluxes	Can be high or low	Weathers to dull gray

simpler to handle. The chart includes two other alloys and 10 single-metal platings. It is designed primarily for comparison purposes. Any of the materials that seem suitable should then be investigated in more detail.

Composition of each alloy coating influences its properties and applications. Here are additional facts about the alloys:

Tin-Copper (bronze) containing up to 20% tin is used mostly as undercoating for other metal finishes. A thin layer of nickel with an undercoat of tin-copper is more corrosion-resistant than the standard copper-nickel-chromium combination. Here, the bronze substitutes for most of the nickel and all of the copper. The bronze or golden bronze color is an attractive decorative finish when lacquered to prevent tarnishing. Speculum coatings, with about 40% tin, are silver-white, non-tarnishing, and are plated on polished reflectors for a highly reflective surface.

Tin-cadmium with 25% tin is superior to cadmium in marine-atmosphere applications and is more corrosion-resistant to organic vapors such as those given off by insulating materials.

Tin-lead alloy electroplate gives additional corrosion resistance over that of tin coatings. The low-melting alloy coatings have excellent solderability and are being plated on printed circuits.

Tin-nickel, deposited ⅔ tin and ⅓ nickel, will substitute for nickel and copper-nickel-chromium coatings to meet decorative needs. Plated coatings on brass have high stability and corrosion resistance. They can replace austenitic stainless steel in balance weights and gear trains for watch parts. The tin-nickel electrolyte has excellent throwing power and will plate into deep recesses.

Tin-zinc provides galvanic protection for steels, plus an excellent solderable coating. Soldering properties are retained in storage. This alloy is also a good undercoat for wrinkle-finish paints. In industrial atmospheres tin-zinc plated steel in contact with aluminum is superior to cadmium.

Brass was the first commercially plated alloy. It gives the appearance of brass to iron and steel parts, and promotes adhesion of rubber to steel and other metals. White brass has a higher zinc content. This bright deposit has good corrosion resistance and can be substituted for nickel.

EDITOR'S NOTE: Design of parts for effective plating was the subject of "Design of Chrome-plated diecastings," May '57, p 190. Design considerations that apply to chrome plating are also valid for other platings.

"Alloy Plating," Sept '55, p 136, deals specifically with this newer development of the plating art, and covers some alloys whose limited use does not qualify them for inclusion in this summary.

Specific processes were covered in "Nickel Plating by Chemical Reduction," July '55, p 148; "Nickel and Chromium Electroplates for Aluminum," Dec '53, p 162; and "Electroless Plating," May '53, p 221.

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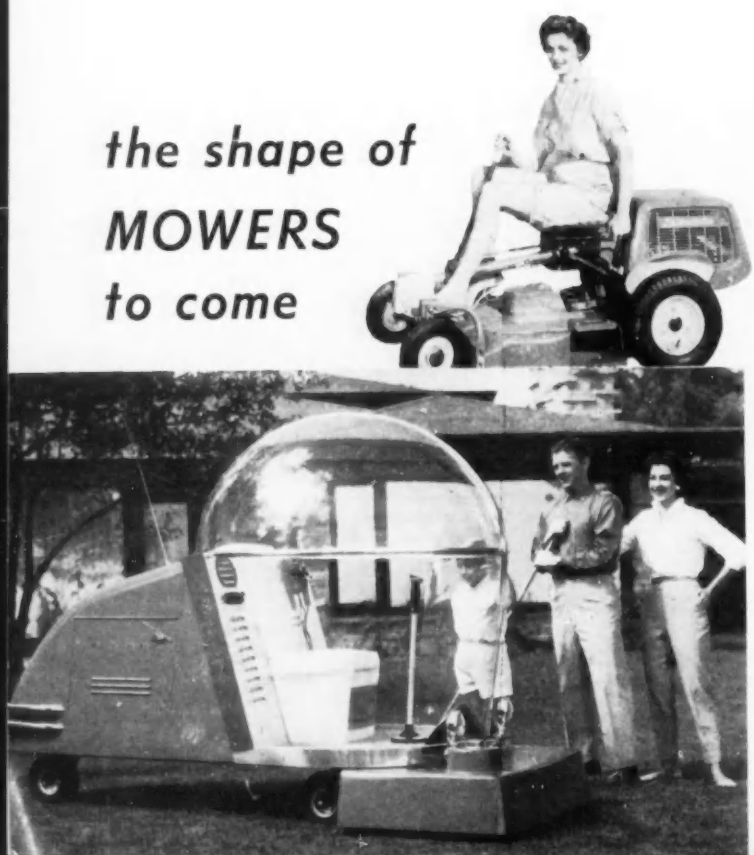
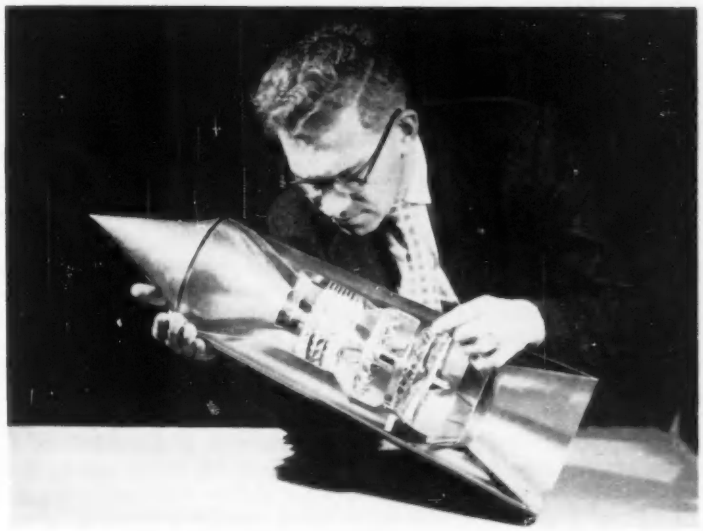
the shape of MOWERS to come



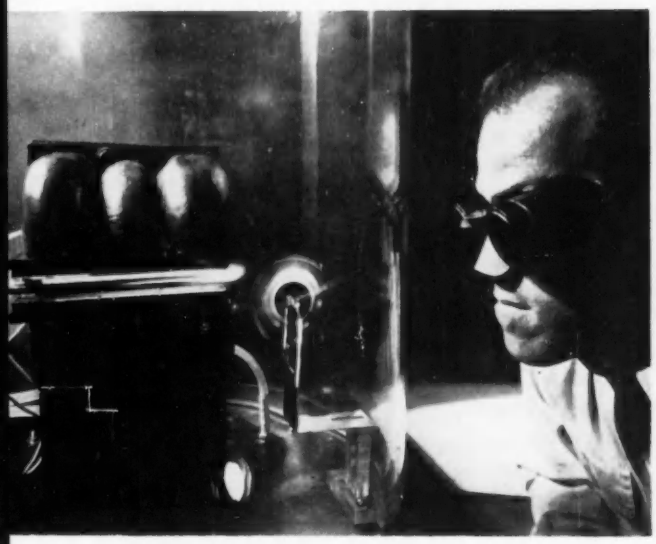
The power motor of the future . . . says Simplicity Mfg. Co., will be a multi-purpose machine that can be driven on the highways, will mow the lawn, weed it, feed it, seed it, spray for insects, plow snow, haul equipment, and provide a handy power-takeoff. It could even be used as a golf cart. It will have radio-telephone, air conditioning, and a cooling system that will provide a chilled drink on a hot day. Naturally, it will provide all-weather protection for the driver.

Simplicity isn't waiting for this futuristic model to go commercial, though, to boost its sales. This past year, it introduced its first gas-engined riding motor, and now (shown with rider) it's adding a two-speed planetary-geared rear axle, increasing horsepower from 3.6 to 4, providing a knob-actuated worm gear for adjusting blade height, and other new features. Simplicity is not the only maker of this type of equipment to offer a brand new model in the past few years. The garden equipment industry is an old one, and long was static, but it's waking up to its opportunities now.



Mach 4 turbojet engine . . .
based on a composite of advanced ideas is displayed in this model at the NACA Lab. The compressor turbine section is dwarfed by the large air inlet and highly expanded exhaust nozzle. The basic engine is much shorter than present engines, using only three instead of 12 to 15 compressor-blade rows. Primary burner and afterburner can be very short if high-energy nonhydrocarbon fuels are used.

Design for Man or Robot?



Ion propulsion . . .
is a futuristic form of jet propulsion detected here by the small wheel behind the jet in test of a model at the NACA Lewis Flight Propulsion Lab, Cleveland. An ion jet is produced when charged particles are formed in an electric discharge between two electrodes, and are eccelerated by a magnetic field. An ion-propulsion unit serving as a low-thrust engine is being considered for use at extreme altitudes.

Fleet and sleek are those planes, on the cover of this issue, that reflect the great strides in aircraft design since the first US jet plane, Bell's P-59 Airacomet, was flown in 1945. That same year, the F-80 was our first jet to get into production. Top speed of both was about 550 mph. One of the latest, and fastest according to most estimates, is the B-58 Hustler (on our cover) which hits about 1327 mph (Mach 2). Also in this speed class are the F-104 and F-105. The F-104 has been described as a "missile with a man in it," and no wonder—it can outrace a 16-in. shell! Planes still in the drawing-board stage will certainly boost speeds considerably, for the trend has been to double aircraft speeds every six years.

But we are now also in a period of transition to guided missiles. This period started with the end of World War II. Unquestionably, the future of air weaponry lies in the missile field, with the not-quite-yet successful ICBM just a sample of things to come.

There are four groups of missiles: surface-to-surface; surface-to-air; air-to-surface; and air-to-air. The last two categories now use more firepower for our manned aircraft. The surface-to-surface and surface-to-air missiles are considered potential replacements for the manned bomber.

Back when aircraft designers first considered the switch to missiles, these were some of the radically new factors which had to affect design thinking: the missile will make only a one-way trip, for it is a single-mission weapon; there will be no pilot and crew; the

Unified Code of Ethics for Hiring Engineering Grads

WASHINGTON–A check-rein on the wooing activities of industries who prowl the US campus for engineering talent is contained in a brochure being circulated to industry, government, colleges and students by the College Placement Council, Inc., and the US Chamber of Commerce.

Entitled "Principles and Practices of College Recruiting," the brochure purports to set up for recruiters a code of ethics that aims to:

1. Promote a wise and responsible choice of a career by the student looking toward long-term investment of his talents.

2. Foster in the student–and the employer–a high standard of integrity.

3. Develop in the student an attitude of personal responsibility for own career and advancement in it, based on performance.

4. Minimize interference with the educational processes of the college, and encourage completion of the individual's plans for further education.

To achieve these objectives, the code lays down a series of do's and don'ts. In essence it tells all concerned to act in good faith throughout the hiring process.

Specifically, it tells the employer not to lure a student with "special payments, gifts, bonuses or other inducements." Elaborate entertaining and overselling are other practices to be avoided by prospective employers. Also, the code tells them not to up the opening salary if a student turns down the initial offer.

There are ground rules for students too. They are told not to play one job offer against the other in an attempt to get higher salaries or fringe rewards; not to pad expense accounts when they make plant visits.

Thirty thousand copies of the code have been circulated to industry, government and colleges. Covering letters, signed jointly by Philip M. Talbott, president of the Chamber of Commerce, and Philip J. Brockway, president of the college council, laid the issue squarely on the line.

Industry's Reaction

Immediate reaction from companies so far has been a flood of congratulatory letters–mainly from presidents or high vp's–praising the measure and pledging to abide by it. They came from some of the largest firms in the automotive, aircraft, oil, and electrical industry.

Most of the companies were quick to point out that they are innocent of malpractice charges. It was the obvious answer. And, it is equally obvious that companies aren't going to admit publicly that they will woo choice college seniors by any possible means–even if they intend to do so.

The real test will come in the next few months when recruiting officers start making their rounds of colleges to scan the coming crop of graduates.

How the Code Came About

The present statement of ethics grew out of several separate codes adopted by regional college placement associations. Back in 1956, the Midwest College Placement Association adopted one. Then, in the spring of 1957, their Eastern counterparts came out with a similar one. Meanwhile, Industrial Relations Advisory Committee of the Manufacturing Chemist's Association prepared a statement of recruiting principles. Other organizations were taking similar action.

To wrap up the various codes, the Chamber of Commerce sponsored a committee that would come up with one version, to be adopted by all. Result is the present code.

McGraw-Hill Forecasts 'Good' 1958, More R&D, Keener Competition

NEW YORK–The year 1958 looks like a good one, and may end up even better, according to the McGraw-Hill Dept. of Economics. Gross national product (roughly our total volume of business) will be about $435 billion this year, $445 billion in 1958. These are the forecasts highlights:

1. Instead of being wonderful, the year will be good, improving at year-end.

2. It will be one of the most competitive years since World War II.

3. More money will be spent on research and development than in any year of our history.

4. Expenditures for new plants and equipment will be down a little from this year's all-time high–the third such high in a row. Expenditures in 1956 were 22% over 1955 for an all-time high, and 1957 will be 7% over 1956. The 1958 decline will still be 12% over 1955 so that the problem is primarily one of analyzing the significance of a decreased increase. Capacity is up 50% since 1950 but production has increased only 38%–apparently we're over-capacitated.

The situation explained in item 4 will create the competitive condition forecast in item 2, a result of trying to keep plants busy. Sales competition will tend to force prices down, rising wage rates will tend to force them up, and business management will be caught in the middle.

Research and development expenditures, resulting from competitive pressure, will be in large measure directed at projects that won't be marketed for several years (It's "7 years from Test Tube to Tank Car"–see Sept 23, p. 32). They'll be well above this year's $7.3 billion, and will result in another capacity upsurge several years from now.

Interesting in our current business checkup is the fact that 90% of companies cooperating can give estimates of their investment for at least three years ahead. Ten years ago, far fewer companies cooperating in such studies could foretell their plans more than a year ahead.

Drastic cuts in military expenditures (from $42 billion to $38 billion) actually will result in increases for a time. Cost of terminating contracts and the like will be heavy. Further, no one knows what our defense expenditures really are–Washington is still figuring those of three years ago. Also, state and local-government expenditures are expected to increase more than federal outlays decline.

Consumer spending is expected to rise about 5% in 1958–it's currently 7% above 1956. But consumers are not buying durable goods like autos and appliances–apparently because

they're not impressed by either the design or sales departments.

The danger signal in the economic forecast is this: The rate of growth of our economy is slowing down. After the end of World War II, our rate of growth was 4.2% per year for 10 years. But since 1955, the annual rate has averaged only 1.6%. Some blame the Federal Reserve tight-money policy, others pooh-pooh that.

In any case, 1958 will be a year of general prosperity, and the most competitive in many years—meaning that management will face a tough test, a test conditioned somewhat by international incident.

Pop-out portable . . .

all-transistor radio developed by Delco Radio Div. and Oldsmobile Div., General Motors Corp., will be offered as an operational accessory on 1958 Oldsmobile models. Measuring 6½ in. long, weighing only 3 lb, the set is easily removed from instrument panel, has playing time of up to 160 hr when out of the car—with four "pen-light" mercury batteries supplying power. Transistor eliminates need for warmup period and dismounted radio has its own built-in speaker and loop antenna. When auto-installed, unit plugs into car's electrical system, also utilizes car antenna and speaker system. Two knobs control station selection and volume.

Army Studies Switch to Aluminum for Unitized Jeep Bodies

DETROIT—Army jeeps in the not too distant future may be equipped with aluminum unitized bodies growing out of the results of durability tests being conducted by government test agencies.

Not that steel unitized bodies haven't been satisfactory—they have. But the need for greater efficiency in military vehicles is ever increasing. In particular, the government requires a jeep that can be run off roads most of the time, that can be transported by air, that can be dropped from the skies and that can float.

In short, Uncle Sam wants a jeep with greater strength-to-weight ratio. An aluminum body weighing 124 lb as compared to a steel body weighing 336 lb may provide the answer.

In 1951 the first unitized body for the jeep was built. It was made of steel and represented a decided improvement over the M-38A1 with separate frame and body. In 1955 Ford was awarded a development contract to design 4 XM-151s (jeeps) with this significant proviso—2 of the four should be equipped with aluminum unitized bodies.

It was decided to make identical aluminum and steel pieces for the new bodies from the same dies using the same material gages. Formability being a primary objective, the search was on for an aluminum alloy with high percentage of elongation yet avoiding heat treatment to achieve hardness. Aluminum alloy 6061 in the T-4 state proved to be the answer.

To meet the required yield strength of 36,000 psi, body parts were assembled as formed. Body assembly was brought up to T-4 hardness by use of a low temperature heating cycle, parts remaining undistorted. Spot welding was the method used to fasten the parts, but there was still the problem of aluminum being 3 times more inclined to buckle than steel using the same material gage.

Design had to accomodate the material. All members had to be designed with a minimum of draw and a maximum corner radii. Large unsupported areas of aluminum—the fenders, side panel and rear panel—could not carry primary loads. Similarly, walls of box members had to be carefully checked.

Continuity of members served to assist in the elimination of many joints. And efforts to place all members directly over the loads to minimize the possibility of loads passing up into the upper body structure were reasonably successful.

A complete structural stress analysis was undertaken, and following numerous adjustments, the design was frozen. Aluminum pieces were made over dies immediately after the steel part had been formed. While 10% of the aluminum pieces were formed without difficulty, die rework and experimenting was necessary with the remaining 90%.

Results of the Army test evaluations are still being awaited.

BUT CIVILIAN CARS STAY WITH STEEL

Military considerations aren't the entire story. Ford has just announced that some 1958 Continental and Lincoln cars (no figures on percentage of total production) will be constructed with a unitized body and frame in the nation's first specially designed unit-frame auto assembly plant in Wixom, Mich.

According to Ford officials, increased torsional rigidity in the body resists twisting from rough road conditions. Welded panels eliminate most body noise characteristics while over-all vehicle height can be increased without reducing passenger comfort.

Torsional-rigidity tests in which a twisting load is applied to the body, to simulate stresses encountered on the road, revealed the "uniframe" structure is 35% more rigid in torsion than the conventional method of construction. A total of 7500 welds of all types are used in this unitized method.

And steel rather than aluminum will be in the structural members—the desire for greater strength-to-weight ratio is not paramount in non-military vehicles.

pilot's skills must be replaced by a series of mechcanical and electronic controls; these components must be 100% reliable under extreme conditions, but in some cases only for a few minutes; the lack of a pilot prevents alternative decisions so that the failure of any part destroys the missile's accuracy and purpose; complete checkout is needed at the launching site because test flight (for a particular target) are impossible; conventional jet engines and fuels are not used; the missile frame is in many instances smaller, and always a simpler structure than the plane it could replace; the missile does not require the many materials and metal-working techniques used for manner aircraft, and does not require large areas for its assembly; and, an interesting advantage, it allows radical ideas to be flown without risking a pilot's life.

The missile is a one-way weapon, many will be required. Also, its ultimate efficiency depends on strength of the enemy, quantity of targets, destructive effectiveness of the missile warhead. So it is still difficult to predict that, even in large quantity, the missile will replace the manned aircraft.

In the last few years the navigational and fire-control systems of the supersonic-manned aircraft have become not unlike those of the guided missile. In most companies, as a result, parallel development is the rule; there has been little actual shift of personnel or facilities from one of these to the other. The consensus is that the same sort of people and equipment are needed for either, with a certain amount of retraining or retooling.

At Douglas Aircraft, major result of the shift to missiles has been to increase the scope of activities of the engineering force. The engineers are divided into groups according to their specialties, and with additional support groups. For a new project, a Chief Project Engineer is assigned with an administrative and technical staff. He draws upon the engineering and support groups, divides the work, then assembles the components. The manufacturer does not attempt to produce everything. The so-called electronic "black boxes" are made by specialist manufacturers.

Hughes Aircraft has had very little to do with the aircraft building industry, concentrating instead on electronic control systems for aircraft, guidance systems for missiles. The missiles are built at the company's Tucson plant. From the design standpoint, Hughes works with a "weapons system," which boils down to missile-delivery-on-target. This system includes the airborne guidance radar which locks in on the target when the pilot has flown the F-102A to the vicinity of the target, the black box that homes on the target and fires the missiles selected by the pilot, and the control of the missiles.

Heat still is the major bogey associated with the design of faster planes, and the even faster and higher-flying missiles. This is a common problem facing the designer of plane and missile structures as well as the engine designer. Huge funds are being spent on research for new materials alone. The lighter metals were adequate for speeds up to just over Mach 2, but at 1500 mph, frictional heat softens the aluminum skin and warps wings. Stainless steel is being used extensively where high skin temperatures are encountered. Honeycomb stainless is used to a great degree on the B-58. The Bell X-2 rocket, which reached a speed of mach 3.5 several years ago, was made entirely of stainless.

There are two schools of thought on material selection for missiles, says the Pentagon. One is that since missiles are expendable, expensive metals should not be used in them. The other view, which has more support, is that high strength materials produce a smaller overall missile that is easier to handle, which helps offset the higher costs.

Also, missiles have a high growth factor. After a certain point, for every pound added to the missile, its structure must be upped 70 lb overall. For aircraft, this factor ranges from 5 to 20.

The emphasis in engine design is toward the use of solid fuels in the IRBM and the ICBM. They are already being used in smaller missiles such as the Sidewinder, the Falcon and the Falcon series. Navy's Polaris IRBM is designed to use solid fuel, but it is still in the development stage.

One problem in using solid fuels for ballistic missiles is that the burning rate cannot be adjusted as can be done with liquid fuels. Another problem is cooling. Benefit of solid fuels is the greater density. Solid fuel motors may be less than half as long as liquid units—with fuel tanks.

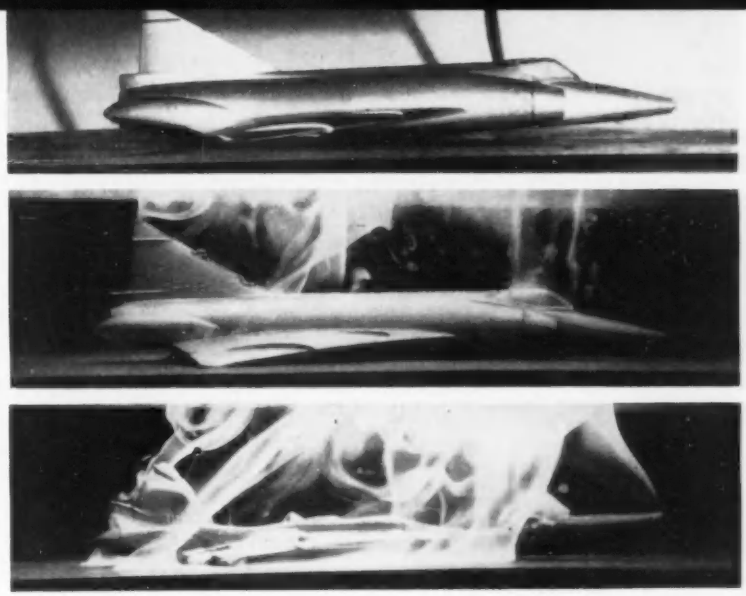
The Air Force has estimated that ultimately, guided missiles will handle about 90% of all air defense missions, 50% of the work of the Strategic Air Command, and 30% of the job of the Tactical Air Command.

We are currently estimating that missile production will increase between now and 1961 from about $2-billion per year to $4-billion per year. During this same period, manned aircraft production will have declined by almost an equivalent amount. In the next five years, 35 to 40% of the Navy's expenditures for air weapons will be for guided missiles. It now takes from 7 to 8 years to place a new supersonic fighter aircraft in inventory with full operational status. To bring a missile to the same status will take just as long, if not longer.

Product's Function Most Important, ASID Head Says

LOS ANGELES—"Functional suitability is the basis of good design," said Jay Doblin, Pres. of the American Society of Industrial Designers in a meeting held just prior to the ASID Conference held Ojai, Cal., Oct. 17-20. He called design "the most powerful sales-stimulant for mass-produced products," and mentioned the automotive and electric-electronic industries as outstanding proof.

Citing the photographic, electronic, office equipment and machine tool industries for producing excellent functional design, Doblin also mentioned areas where considerable improvement is possible. "Automobile designers," he said, however, "have worked themselves into a corner emphasizing fashion and style as selling points rather than functional suitability. A technological break-through, such as adoption of turbine engines is needed to permit redesign to provide better weight distribution, better traction and braking, improved visibility, and low silhouette without sacrificing riding comfort."



Heat at supersonic speeds . . . destroys plastic airplane model in 6-sec time interval recorded by these three photos taken at new test facility developed by Westinghouse. Designed to simulate heat hazards of supersonic flight, the setup has quartz infrared lamps that can build up temperatures to 2500 F in 12 sec. From 20 to 30 banks of these lamps are used with full size aircraft structures, and spread on like a blanket. Each unit can be set at a different temperature to simulate various temperatures encountered in flight. A computer can be set to control temperature variations throughout the test.

"Now, when there is relatively little time left . . ."

Our World News office in Vienna recently reported Moscow Radio had announced on Aug. 31 that an entire series of satellites would be launched by the Soviet Union during the 1957-58 Geophysical year. The announcement also gave a few details of the missile that would carry this satellite.

This was not news; for Russia had repeatedly announced its intentions to launch a satellite during IGY, and facts on its rockets have been known to US scientists for some time. But rereading the "official release" in light of Russia's success uncovers some interesting facts. Moscow's statement said:

"Theoretically a satellite could be constructed that could later be salvaged, descending to earth by parachute, but these first satellites will not be of this kind. For this reason, whatever observations are made from the satellite will be transmitted to earth by radio, and in order to do this, the data collected will be recorded by special electronic and other devices and then transmitted to earth all at once, within a short space of time. These radio signals from the satellite will be relayed all over the world.

"All kind of measuring instruments will be installed in the artificial satellite. Air pressure will be measured by an ionization mamometer; composition of the air will be determined by a radio frequency mass spectrometer, which can detect the presence of ionized atoms of different gases and determine their concentration. Devices will measure the quality and energy of meteor particles and cosmic rays. Special attention will be given to optical measurements, getting spectra of the sun and stars from outside the earth's atmospheric envelope, observing the luminescence of the atmosphere itself. In addition, instruments will measure the magnetic field of our planet.

"All the instruments in the satellite can be powered by a small, high-capacity storage battery, but since such batteries have a short life, it is probable that the power will be obtained from a more complex arrangement consisting of the same type of storage battery, but with a device attached for changing solar energy into electricity. In this way, the batteries can be constantly recharged.

"So much for satellites carrying instruments and used primarily for taking measurements. Let us talk for a minute about another use for satellites. There are plans to launch a different kind of satellite, without instruments of any sort. This type will be observed from the earth through telescopes, making it possible to calculate precise distance on earth and to determine the shape of the globe and its irregularities. This satellite will be called the 'beacon' and will probably look brighter to us than a star of the first magnitude.

"The satellites carrying the instruments will be hollow aluminum spheres, 25 in. in dia, weighing about 22 lb. Everything must be small, durable, light in weight and capable of operating on a small supply of electricity."

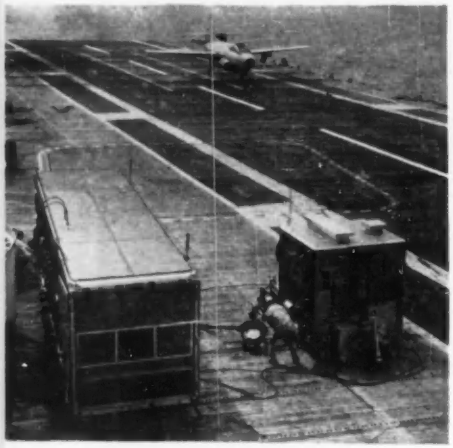
> [That 22 lb sphere is a far cry from the 184 lb Sputnik actually launched three weeks ago. And the "everything must be small . . . light in weight . . ." dream must have backfired. The transmitter is known to be of one watt capacity, and to last two weeks a US scientist estimates the battery weight for this output to be about 90 lb. Just recently, a Moscow statement said Russia will launch, "within a month or two," a second satellite weighing two to three times the first one.]

"Observation stations," the official release continues, "are located at many different points all over the nation—in Riga, at Leningrad, in the Caucaus, in Novosibirsk and Siberia. At Novosibirsk, radio and recording apparatus is being set up to collect the information from the satellite.

"Now, when there is relatively little time left before the first satellite is launched, intense preparatory work is going on at these observation stations."

How little time? If we had only realized! Just one month, plus a few days.

All-electronic Landing System Makes Good — but Buyers Not Ready



Flattop touchdown . . .
is scored by Navy F3D aboard USS Antietam using Bell Aircraft's all-weather, automatic landing system. Radio-radar system, regulated by computers, takes over control of aircraft from pilot, sends necessary course corrections to automatic pilot, for safe, accurate landing.

BUFFALO—An all-weather automatic landing system for planes is now proved—but still five years away from large-scale commercial application.

In recent Gulf of Mexico tests aboard the carrier USS Antietam, a Navy pilot made repeated landings without touching his controls—an important first. Commercial application of the system, designed for the Navy, will be delayed, however, because of the variety of other systems and cost of replacing them.

Here's how it works: radar pinpoints the aircraft when it is one to four miles away from the carrier. Radio "locks" it in, and a computer takes over to give flight commands. The pilot becomes virtually a passenger until touchdown.

If the carrier is not in proper position for safe landing, a "Wave-off" signal is flashed to the pilot who can then cut out of the pattern and make a new approach. The pilot can override the autopilot at any time. Bad weather poses no problem.

Carrier deck equipment includes one radar cube, three computers and a monitoring console—the cube mounted on a mobile dolly, the computers and console housed in a trailer. In the plane is only a 3-lb corner reflector mounted on the landing gear. The reflector signals "Lock-on" and "Wave-off" orders to the pilot.

A stabilization computer in a trailer on deck uses two integrating gyros and 10 receivers that feed carrier roll, pitch and yaw variations to the flight-path computer in the same housing. A prediction computer takes into account six types of ship movement—roll, pitch, yaw, heave (up-and-down motion), sway (side-to-side motion), and surge (back-and-forth motion). These additional devices, not necessary with ground installations, enable incoming aircraft to adjust to varying conditions of the ship. In both versions, however, the system is a closed-shop, air-to-ground servo.

Chief advantage of the system for the Navy is the reduction of landing dispersal, which means increased landing accuracy. Until now Navy has required that an automatic system land a craft with no more than 30-ft longitudinal and 35-ft lateral error. In more than 100 landings, the Bell system landed planes with average longitudinal dispersion of 18 ft and negligible lateral dispersion.

The system also speeds up landing group of planes. Some 120 craft were landed within an hour during a recent test.

Bell representatives reported that at this date no production order for the system has come from our Navy.

COMING EVENTS

OCTOBER

28-30 . . . National Lubricating Grease Institute, 25th annual meeting, Edgewater Beach Hotel, Chicago.

28-30 . . . Aeronautical and Navigational Electronics, 4th annual East Coast conference, sponsored by Baltimore section, Institute of Radio Engineers, Fifth Regiment Armory, Baltimore, Md.

27-Nov. 1 . . . International Atom Week, sponsored by the Atomic Energy Forum and American Nuclear Society. Conference programs include: 4th annual atomic industry conference; 2nd winter meeting American Nuclear Society; 2nd annual conference, Careers in Nuclear Science and Engineering; Conference on Reactor Safety, and Annual Conference, Nuclear Science Group.

28-30 . . . National Industrial Packaging and Handling Exposition by Society of Industrial Packaging and Materials Handling Engineers at Conventional Hall, Atlantic City, N. J.

30-Nov. 1 . . . Executive Technicians for Industrial Engineering, sponsored by Industrial Management Society. Hotel Sherman, Chicago.

NOVEMBER

2-8 . . . 2nd World Metallurgical Congress and 39th National Metals Exposition and Congress sponsored by American Society for Metals, the Atomic Energy Commission, American Institute of Mining and Metallurgical Engineers, Society for Nondestructive Testing, Industrial Heating Equipment Association, Metal Powder Association, and Special Libraries Association.

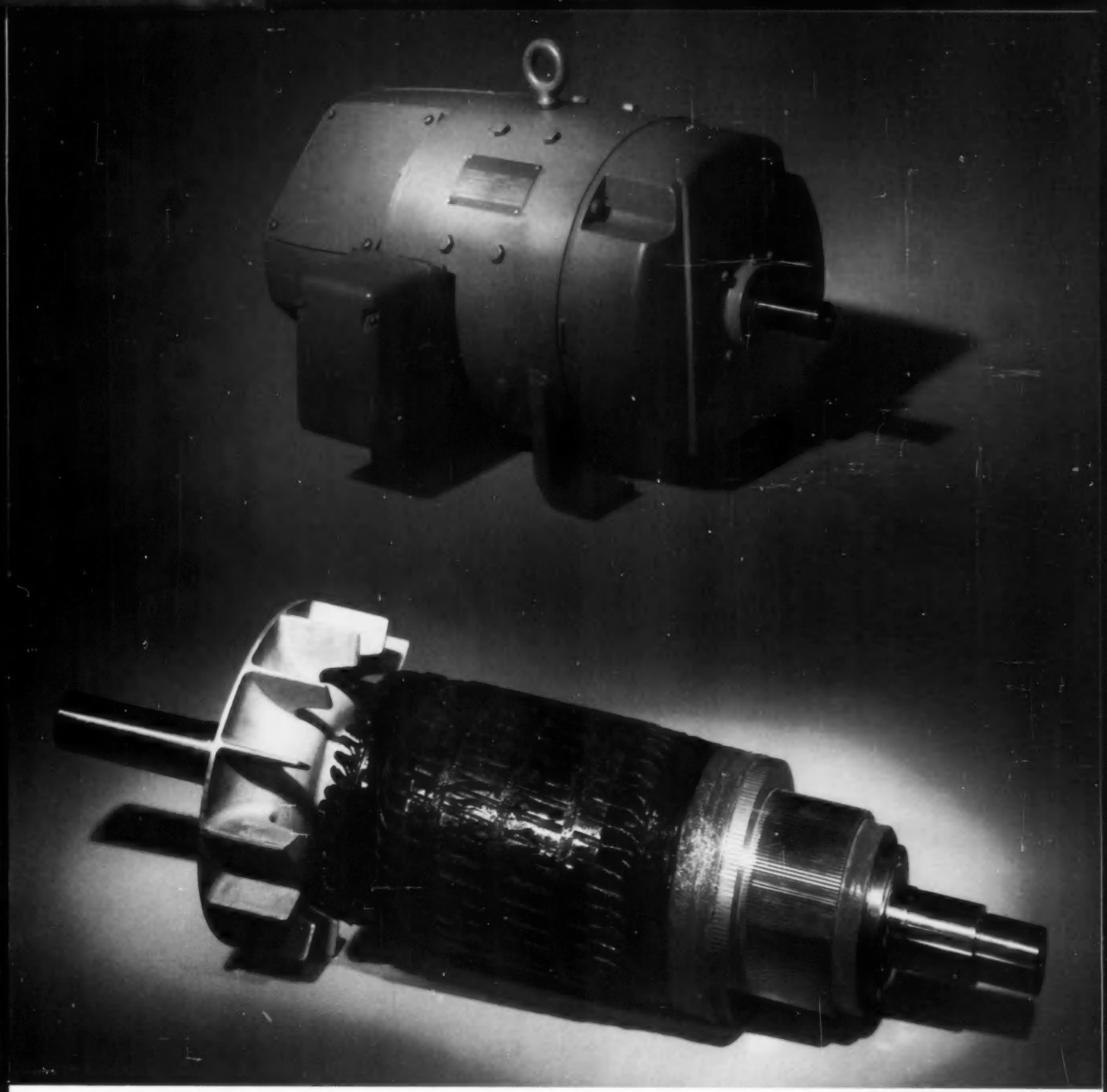
4-6 . . . 9th annual AIEE Machine Tool Conference, Hotel Schroeder, Milwaukee, Wis.

4-8 . . . SAE conferences: National Transportation, National Diesel Engine, and National Fuels and Lubricants Meetings at Hotel Statler, Cleveland, Ohio.

11 . . . Plastics for Air-Borne Electronics, Regional Technical Conference, Society of Plastics Engineers, Sheraton-Cadillac Hotel, Detroit.

12-14 . . . National Association of Corrosion Engineers, Northern Regional meeting, Penn-Sheraton Hotel, Pittsburgh.

13-15 . . . National Conference on Standards sponsored by American Standards Association, St. Francis Hotel, San Francisco.



NEW GENERAL ELECTRIC DC MOTOR GIVES

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KINAMATIC* . . . a new standard in industrial direct current motors . . . designed to deliver drive power at the moment you need it!

Split-Second Response . . . larger air gaps reduce electrical time constants . . . smaller armature diameter permits more rapid delivery of torque to load . . . means faster starts, stops, reversals.

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Other Power Packed Features of new d-c Kinamatic motors help give you more continuous, more automatic production . . . economically.

Additional information is available at your nearest General Electric Apparatus Sales Office. Or, if you prefer, write for Bulletin GEA-6355. *Direct Current Motor and Generator Department, Erie, Pennsylvania.* 813-9

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TAYLOR FIBRE CO.
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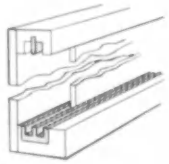
PHENOLIC—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • COPPER-CLAD LAMINATES • VULCANIZED FIBRE

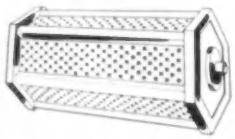
Tips for designers

Terminal board for a complex circuit in an electronic spectrophotometer is made of Taylor Grade LE laminate . . . selected for its insulating and mechanical properties.

Gas pump impeller unit is fabricated of Taylor Grade LE-6 phenolic laminate . . . economical, light-weight, wear-resistant . . . chosen because of strength, stability.



Guides for sliding doors, made from Taylor vulcanized fibre, last longer because of high strength and resistance to abrasion.



Metal plating barrels of Taylor Grade C-5 melamine withstand corrosion and erosion successfully in alkaline solutions. Downtime and maintenance costs are substantially reduced.

TAYLOR SUPERIOR COPPER-CLAD LAMINATES

Taylor GEC (glass epoxy) Copper-Clad and Taylor XXXP-242 cold punching (paper-phenolic) Copper-Clad. Taylor uses high purity rolled copper on base materials with outstanding electrical properties.

This coil form for radio frequency transformers is fabricated by Taylor of Grade XX laminate plastic tubing for Collins Radio Co. The O.D. of the center section is held to a tolerance of .230" ± .0005". Material was chosen for its good electrical properties, dimensional stability and machineability.

Precise electrical insulation parts? Taylor can produce them.

This coil form for radio frequency transformers was produced by Taylor's Fabricating Division, holding the tolerance of the outside diameter of the center section to ± .0005".

Taylor has special techniques and facilities capable of providing parts—such as this coil form—to your own specifications, promptly and economically. You can shorten your production steps by putting Taylor to work for you . . . simplifying production . . . safeguarding schedules . . . reducing overall costs.

Precision fabrication of laminates and vulcanized fibre is difficult . . . but Taylor can and is doing it, in a great variety of Taylor grades, and to extremely close tolerances. In your present products or in those that are now on your drafting boards are opportunities for you to take advantage of Taylor's equipment and experience. Design to closer tolerances—Taylor can handle the job. Taylor is equipped to handle any type of fabrication—punching, drilling, grinding, forming, milling or turning—simple or complex.

Chances are that Taylor's staff of specialists can help you with design, material selection and fabrication. Call or write your nearest Taylor sales office for a talk about your needs.

OVER-DESIGNING?

If you are designing bronze parts for mass production, there is a good chance that you are specifying a more costly alloy than you need.

ASARCO's patented continuous-casting process produces alloys according to SAE, ASTM and Government specifications. But their performance is entirely unlike that of similar alloys cast in sand or permanent molds. Relatively low-cost alloys cast by the ASARCO process perform like more expensive alloys cast by other methods.

For example, compare Continuous-Cast SAE 660 (ASARCON 773) with more expensive sand-cast alloys:

	Typical Yield Strength	Typical Impact Strength	Brinell Hardness
ASARCON 773	27,000 psi	12.5 ft.-lbs.	72
Sand-Cast SAE 62	20,000 psi	8.7 ft.-lbs.	65
Sand-Cast SAE 64	17,000 psi	8.2 ft.-lbs.	62

Unless you've checked to see whether the unique ASARCO bronzes can give you what you need, there's a possibility that you're over-designing. You may even be able to replace aluminum and manganese bronzes with low-cost ASARCON Continuous-Cast bronzes under certain conditions. Over-designing can be expensive in mass production, even if you are spending only a penny or two extra per pound of bronze.

ASARCON 773 (SAE 660) is readily available from stock in a wide range of sizes. An added bonus is the fact that ASARCON 773 is exceptionally free-machining. Rods, tubes, and numerous "extruded" shapes up to 9 inches in diameter are cast to order by ASARCO in more than 20 alloys.

We'll be happy to send you a free booklet describing the process and the product.

Continuous-Cast Products Department

AMERICAN SMELTING AND REFINING COMPANY

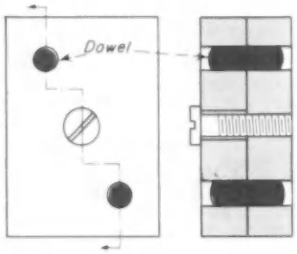
Perth Amboy Plant, Barber, New Jersey • Whiting, Indiana

WEST COAST SALES AGENT: Kingwell Bros. Ltd., 457 Minna Street, San Francisco IN CANADA: Federated Metals Canada, Ltd., Toronto and Montreal

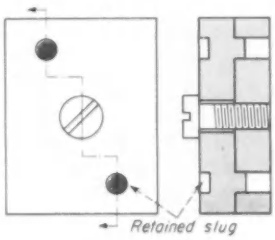
16 Ways to Align Sheets and Plates

FEDERICO STRASSER, *Santiago de Chile*

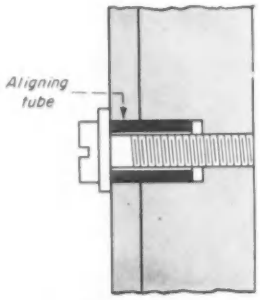
Two Flat Parts



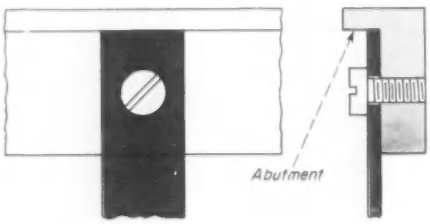
1 Dowels . . .
accurately align two plates, prevent shear stress in fastening screw. Two pins are necessary because screw can not act as aligning-pin.



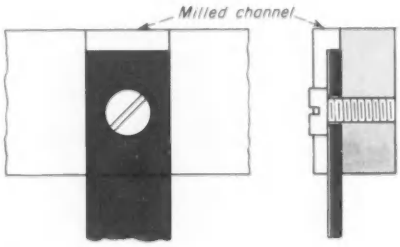
2 Retained slugs . . .
act as pins, perform same function as dowels; are cheaper but not as accurate.



3 Aligning tube . . .
fits into counterbored hole through both parts. Screw clearance must be provided in tube.

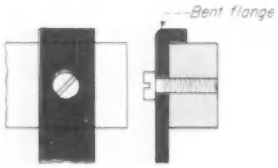


4 Abutment . . .
provides positive, cheap alignment of rectangular part.

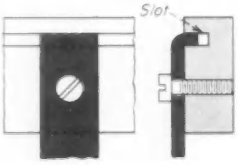


5 Matching channel . . .
milled in one part gives more efficient alignment than abutment in preceding method.

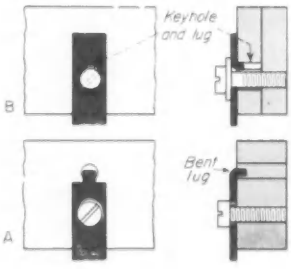
Formed Stampings Assembled with Flat Parts



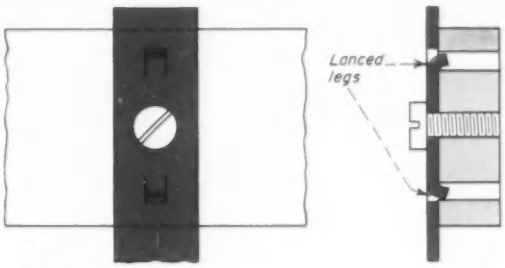
6 Bent flange . . .
performs similar function as abutment, but may be more suitable where machining or casting of abutment in large part is not desirable or practical.



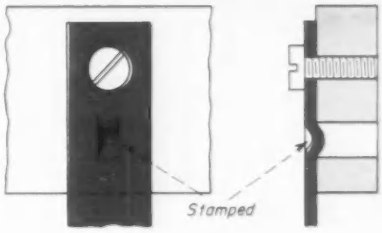
7 Narrow slot . . .
receives flange or leg on sheet metal part, allows it to be mounted remote from edge of other part.



8 Bent lug . . .
(A) fits into hole, aligns parts simply and cheaply; or (B) lug formed by slitting clearance hole in sheet metal keys parts together at keyhole.

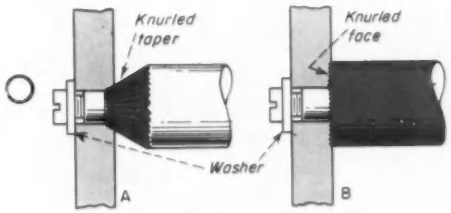


9 Two legs . . .
formed by lancing, align parts in manner similar to retained slugs in method 2, but formed legs are only an alternative for sheet too thin to partially extrude slug.

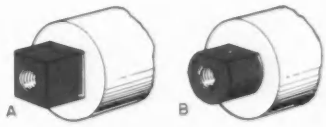


10 Aligning projection . . .
formed by slitting and embossing is good locating method, but allows a relatively large amount of play in the assembly.

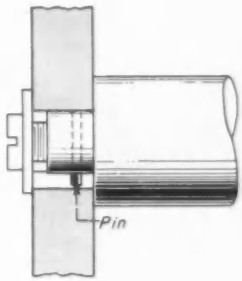
Flat Parts and Bars



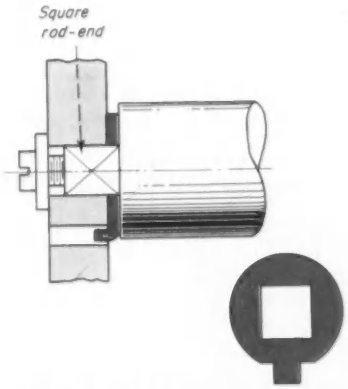
11 Knurled end . . .
of round bar (A) has taper which digs into edge of hole when screw is tightened; this gives accurate angular location of bar or sheet. (B) Radial knurling on shoulder is even more positive.



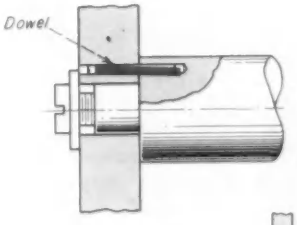
12 Noncircular end . . .
on bar may be square (A) or D-shaped (B) and introduced into a similarly-shaped hole. Screw and washer hold parts together as before.



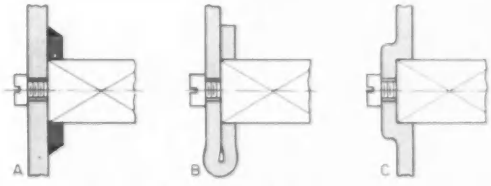
13 Transverse pin . . .
in rod end fits into slot, lets rod end be round but nonrotatable.



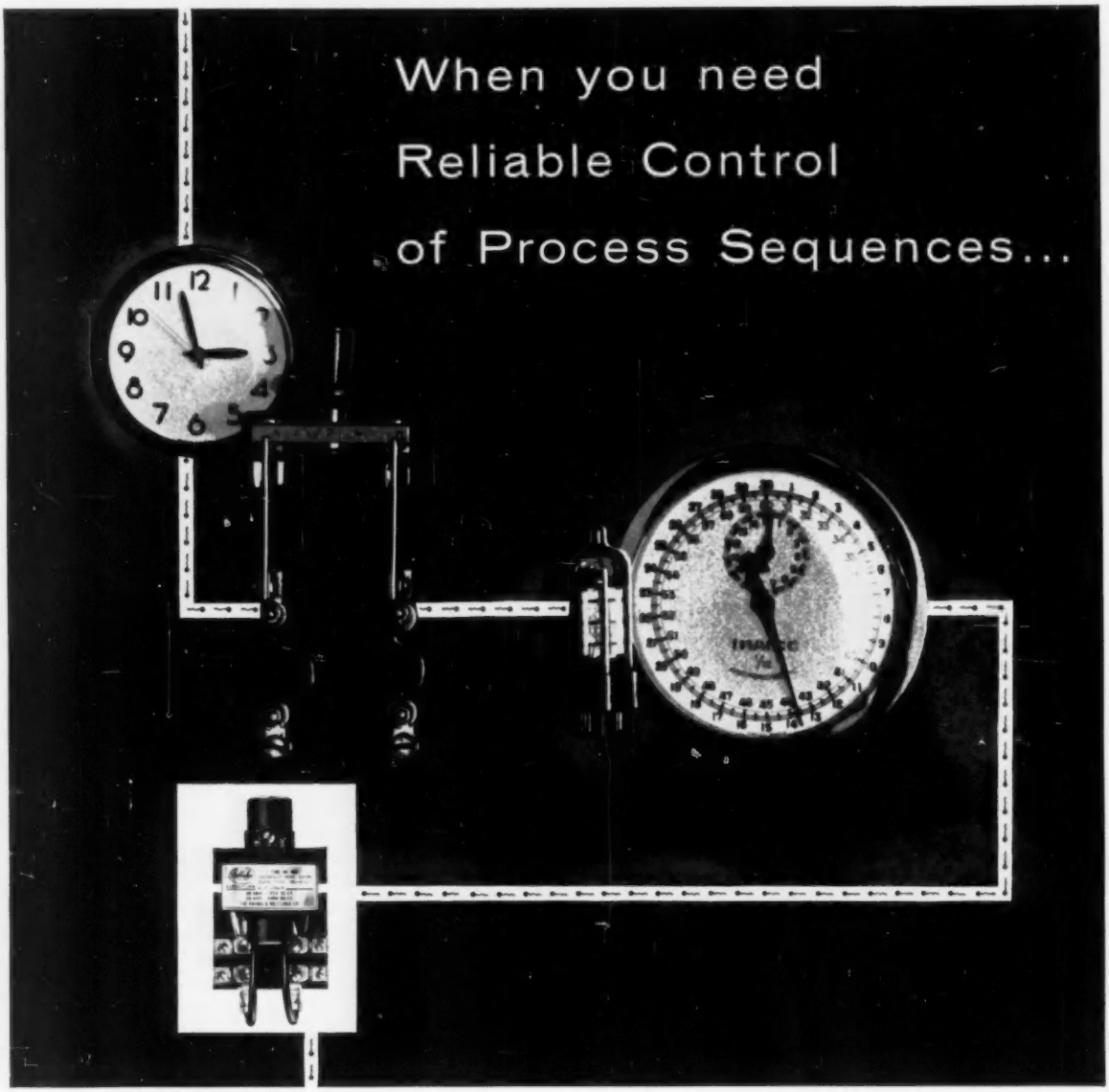
14 Washer over square rod end . . .
has leg bent to fit in small hole. Washer hole is square, preventing angular movement when all three parts are assembled and fastened with screw and washer.



15 Dowel . . .
is simple, efficient method of preventing rotation if rod dia is big enough.



16 Double sheet thickness . . .
allows square or hexagonal locating-hole for shaft end to be provided in thin sheet. Extra thickness can be (A) welded (B) folded or (C) embossed.



you need **Adlake** *mercury-to-mercury* relays

- **Mercury-to-Mercury contact of Adlake Relays gives ideal snap-action with no pitting, sticking or burning.**
- **Hermetically sealed at the factory so dust, dirt, moisture cannot affect them.**
- **Time delay characteristics are fixed and tamper-proof.**
- **Adlake Relays are quiet, chatterless and require no maintenance whatever.**

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Adlake 100th ANNIVERSARY 1857-1957

The Adams & Westlake Company

NEW YORK ELKHART, INDIANA CHICAGO

original and largest manufacturers of plunger-type relays

Which RIVET To Use — I

The where, what and how of different types of rivets, tabulated for quick reference.

by **HENRY PETERSON,** *Chief Engineer Judson L. Thompson Mfg. Co.*

	Where to Use	Advantages	How Clinched	Dimensional Data:
SEMI-TUBULAR HD – head dia HT – head thickness SD – shank dia L – rivet length G – permissible corner radius T – hole depth	To fasten two or more sections permanently through predrilled or prepunched holes – at lowest possible cost.	Combines the high shear and compression strength of solid rivets with quick, easy clinching on high-speed automatic rivet-setting machines.	Roll clinch or scored clinch. Roll clinch is strongest. Scored method is best when the clinch must be turned into the surface of the assembly.	T – generally approximates SD. Depth determined by clinch requirements of specific applications. HD – 1.75 to 2.75 SD for rivets produced by single-die heading machines. Head diameters up to 3.5 SD are possible. HT – 0.3 to 0.6 SD. SD – 0.040 in. to 0.380 in. L – 0.6 to 15 SD. Exact length generally determined by adding 55% of SD to thickness of materials to be fastened. G – of corners 0.003 to 0.030 depending on SD and head size.
Standard head shapes of semitubular and deep-drilled rivets. Oval Flat countersunk Ideal for tinners Flat countersunk with bevel Cone				
DEEP-DRILLED	Permanent fasteners that punch their own holes in leather, plastics, rubber, wood, canvas and other easily pierced, compressible materials.	Eliminate cost of prepunching or predrilling holes in materials to be fastened. They punch their own holes through the material and compress it within their hollow shanks. Clinched by high-speed automatic rivet-setting machines, which can be operated by unskilled help, they keep assembly time and costs at a minimum.	Roll clinch or scored clinch. Roll clinch is strongest. Scored method is best when the clinch must be turned into the surface of the assembly.	D – exceeds shank diameter but is never deeper than ½ in. Exact depth determined by compressibility of materials to be fastened and by clinch requirements of each application. Safe rule is to have tests run on actual samples. HD – 1.75 to 2.75 SD depending on head shape SD – 0.040 to 0.380 in. L – 0.6 to 15 SD. Exact length generally determined by adding 55% to thickness of materials to be fastened. G – of corners 0.003 to 0.030 depending on SD and head size.

is yours* still in the question stage?
Many product engineers find it advantageous to consult us before setting specifications for spring action. Working with all types of materials, and with expert tool design facilities, we can often effect economies right at the start. Let us show you how it works. Consult our engineers without obligation. Write for free pamphlet – "Spring Design and Selection – in brief."
WALLACE BARNES COMPANY
BRISTOL, CONNECTICUT
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1800 CLYBOURN AVE. CHICAGO 14.
RAYMOND Manufacturing COMPANY
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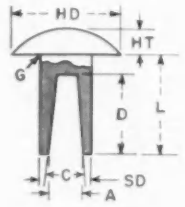
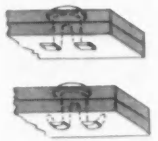
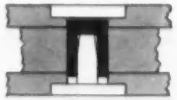
Which RIVET To Use — I *(continued)*

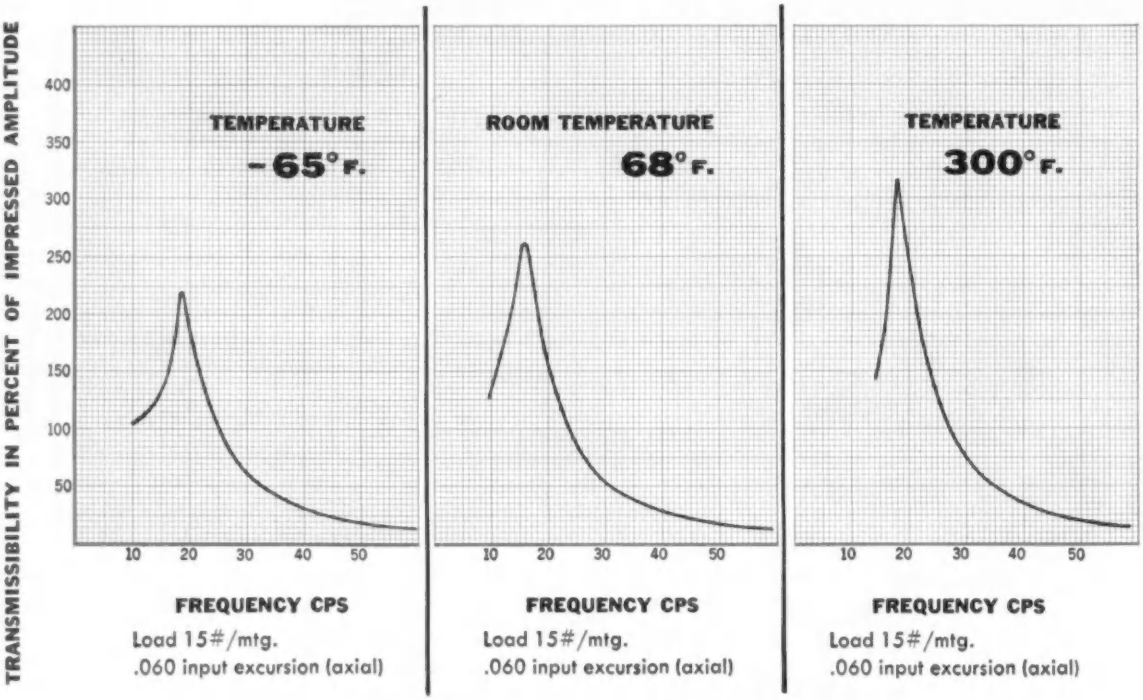
BIFURCATED	Where to Use	Advantages	How Clinched	Dimensional Data:
 A — slot width (bottom) D — slot depth C — angle of slot opening	Self-piercing permanent fasteners for such materials as light metal (up to 0.040 in. thick) wood fiber, leather, webbing, and some plastics.	Eliminate delay and cost of prepunching or predrilling holes; avoid weakening the assembly by removing material. Applied by high-speed automatic rivet-setting machines, they reduce assembly time and costs to a minimum.	By anvils that either spread the prongs flush with the surface or turn them into the material. When a stronger bearing surface is required to prevent the clinch from tearing loose, the prongs are clinched against burrs (washers) or inside caps. 	*HD* – 1.75 to 2.75 for rivets produced by single-die heading machines. Head diameters up to 3.5 are also possible. *HT* – 0.3 to 6 *SD* depending on head shape. *SD* – 0.040 to 0.380 in. Slot *A*, *B*, and *C* – vary with each application, depending on thickness and hardness of materials and strength requirements of the clinch. Tests on actual samples are recommended in all cases. *L* – 0.06 to 15 *SD*. Exact length generally determined by type of application. *G* – at corners 0.003 to 0.030 in. depending on shank diameter and head size.

Standard Head Shapes of Bifurcated Rivets

COMPRESSION (cutlery type)				
chamfered shank, press fit in hole	Primarily for attaching knife handles (heads may be trimmed for close tolerance); also as hinge pins or through handle brackets.	Fit snugly into counterbored holes. Provide smooth projectionless surface on product as well as strong press fit.	Press-fitted by machine. 	Head dia: ¼ in. to 7/16 in. Shank dia: 0.150 in. to 0.195 in. (female). Length: ¼ in. to ¾ in.

Product Engineering
BOOK SHEET
ENGINEER

Broad Temperature Range elastomers for LORD bonded rubber mountings



BROAD TEMPERATURE RANGE — Transmissibility curves for LORD Mounting with new type *BTR* elastomer indicate that temperature extremes produce minimum change in physical properties. Transmissibility at resonance is three or less at 68°F. or lower temperatures, and 3.5 or less at 300°F.

■ A new type Broad Temperature Range elastomer with resistance to temperature extremes is now available from LORD Manufacturing Co.

This new material is used in performance-proved LORD mounting designs to assure superior vibration isolation under severe environmental conditions. It is resistant to oil and ozone, and functions efficiently in temperature ranges from −65°F. to 300°F. Its proven mechanical properties include high tensile strength, high tear resistance, and good flex life. The hysteresis characteristic of the material eliminates the need for auxiliary dampers, which generate harmonics destructive to mounted equipment.

For further information on this new elastomer, contact your nearest LORD field engineer or the Home Office, Erie, Pa.

ATLANTA, GEORGIA · CEdar 7-1123
BOSTON, MASS. · HAncock 6-9135
CHICAGO, ILL. · Michigan 2-6010
CLEVELAND, OHIO · SHadyside 9-3175
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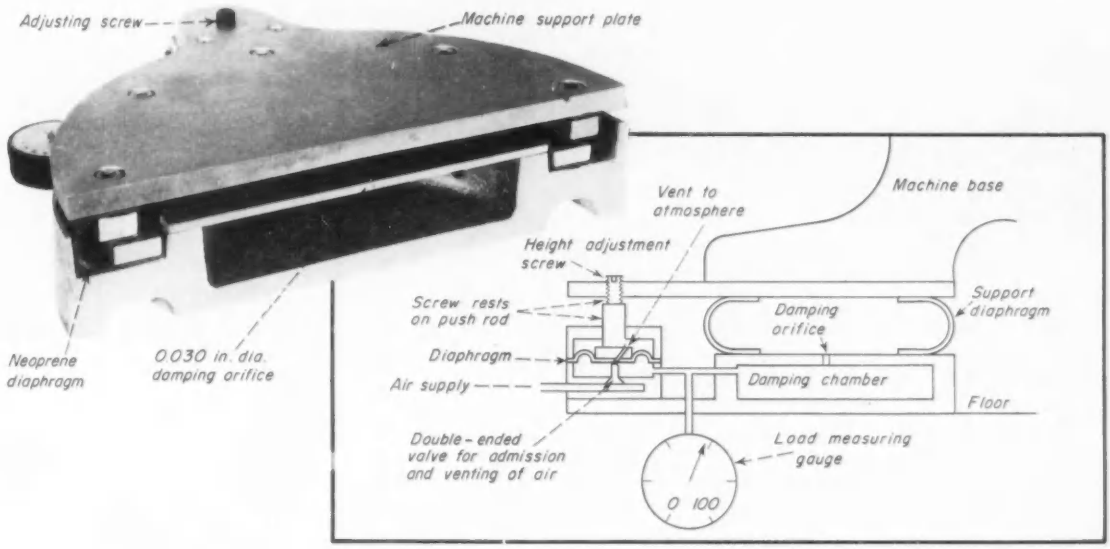
designers and producers of bonded rubber products since 1924

NEW COMPONENTS and MATERIALS



Air Pressure Measures Machine Level, Isolates Vibration

This pneumatic machine-mounting system consists primarily of an air cushion with pressure gage. Pressure in the cushion is registered when the unit is inserted under a machine support point. Multiplying this pressure by effective area of the mount gives total push of the mount against machine support—equivalent to load carried by that support.

Setting the machine in a particular position gives a set of readings for mounts supporting the machine. These are recorded in any convenient way (a crayon mark on the gage glass will do). To check machine level it is only necessary to reset the machine in its standard position; a change in gage readings indicates a redistribution of the machine weight that signifies movement of part of the foundation. Such movements are very small, at least at the start, but they can produce extraneous stresses in various members of the machine.

Very often these movements are simply a resettling of the ground under the machine, and only a small adjustment will re-establish proper loading—either by admitting more air into the cushion, or venting some of it to the atmosphere. Air is obtained by connecting each mount to the factory air supply (100 psi).

At present, adjustment is by hand, although an automatic system is coming. To increase load carried by a mount, the height-adjustment screw is turned clockwise. Axial motion of the screw is transmitted through push rod and diaphragm to a double-ended valve that admits high-pressure air to the cushion. A damping chamber and damping orifice prevent sudden surges of air into the main support chamber and eliminates "hunting."

Additional air increases pressure in the main support chamber and lifts the machine support plate, giving additional support to the machine at that point. As the plate lifts, pressure of the height-adjustment screw on the push rod is released; the valve is seated, and no more air is admitted.

Turning the height-adjustment screw counterclockwise allows diaphragm and push rod to move away from the double-ended valve, opening the air vent to the atmosphere. Some of the air escapes, and the machine support plate lowers, reducing the load carried by that particular support. As the plate is lowered, the height-adjustment screw again pushes against the push rod. This lowers the diaphragm onto the valve and the latter responds by shutting off the vent.

Effective air-pressure area in the mounts now in production is 120 sq in., making possible a max load of 12,000 lb with 100-psi air supply. A smaller mount, with max load of 6,000 lb, will be available soon.

These mounts isolate the machine from vibrations transmitted through the floor, as well as prevent transmission of vibrations and shocks generated in the machine.

Application to truck and trailer bodies is expected to help prevent improper loading, distribute weight over all the wheels, and help reduce both road accidents and truck breakdowns.

Another advantage claimed is elimination of special foundations, which account for much of the cost of installing heavy machine tools.

The mounts are lightweight, all major parts being made of machined aluminum castings. The support diaphragm is of nylon-reinforced neoprene. Cost is about the same as that of normally used spring mounts. Price, $85; availability, 2 to 3 wk. **Weber Instrument Co., 11301 Schaefer Road, Detroit 27.**

For more information—
Circle 1, inside back cover

CONTINUED ON PAGE 102

Air Motor for High-temperature Service

An air motor has been developed that operates at temperatures over 1000 F without conventional lubrication or cooling. The cam-piston motor, a positive-displacement, fluid-drive device worked by hot compressed air, is being produced in three sizes, varying in over-all length from 9 to 13 in. Power ratings range from 1 to 300 hp. It weighs 22 lb, has a 18.5-hp output at a low rpm.

Current uses include power actuation for airplane control surfaces and for jet-engine thrust reversers and exit nozzles. Motor output is nearly linear. Inlet pressure allows maximum efficiencies through a wide range of operating conditions. Maximum hp-to-weight ratio and high starting and braking torque have been obtained by designing for max cu-in. displacement per revolution of the motor.

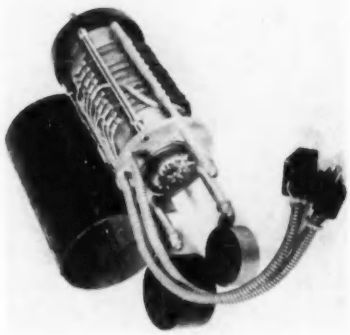
Low rotating speeds of the motor, 100 to 2500 rpm, eliminates need for gear reduction in most applications, minimizes problems of excessive wear without lubrication, high rotational stresses, and overspeed control. Acceleration is less than 0.05 sec. Low air consumption is a function of the fixed displacement volume, speed, and inlet density. Standard units are now in production. **Airesearch Mfg. Div., Garrett Corp., 402 S. 36th St., Phoenix, Ariz.**

For more information—
Circle 2, inside back cover

Mercury Slip Ring

This slip ring, is for heavy-current high-speed (over 20,000 rpm) applications; it uses mercury, instead of solid brushes and rings, for electrical contact between moving and stationary parts. It is designed for use with strain gages or thermocouples, in connection with rotating assemblies such as compressors and turbines. The "noise level" of the unit is negligible and service life is indefinite, since no solid parts are in contact.

Cooling of the mercury is provided on all rings, using machine oil or any non-



conducting liquid compatible with neoprene seals. Mercury is fed through system manifold at 10-lb pressure. Contact surfaces of the rings are blanketed with dry nitrogen during operation (feed rate is low enough, so 40-hr operation is possible on the average-size tank). Price of 10-ring unit is around $1200; delivery, 6 wk. **Aerotech Specialties Inc., Glastonbury, Conn.**

For more information—
Circle 3, inside back cover

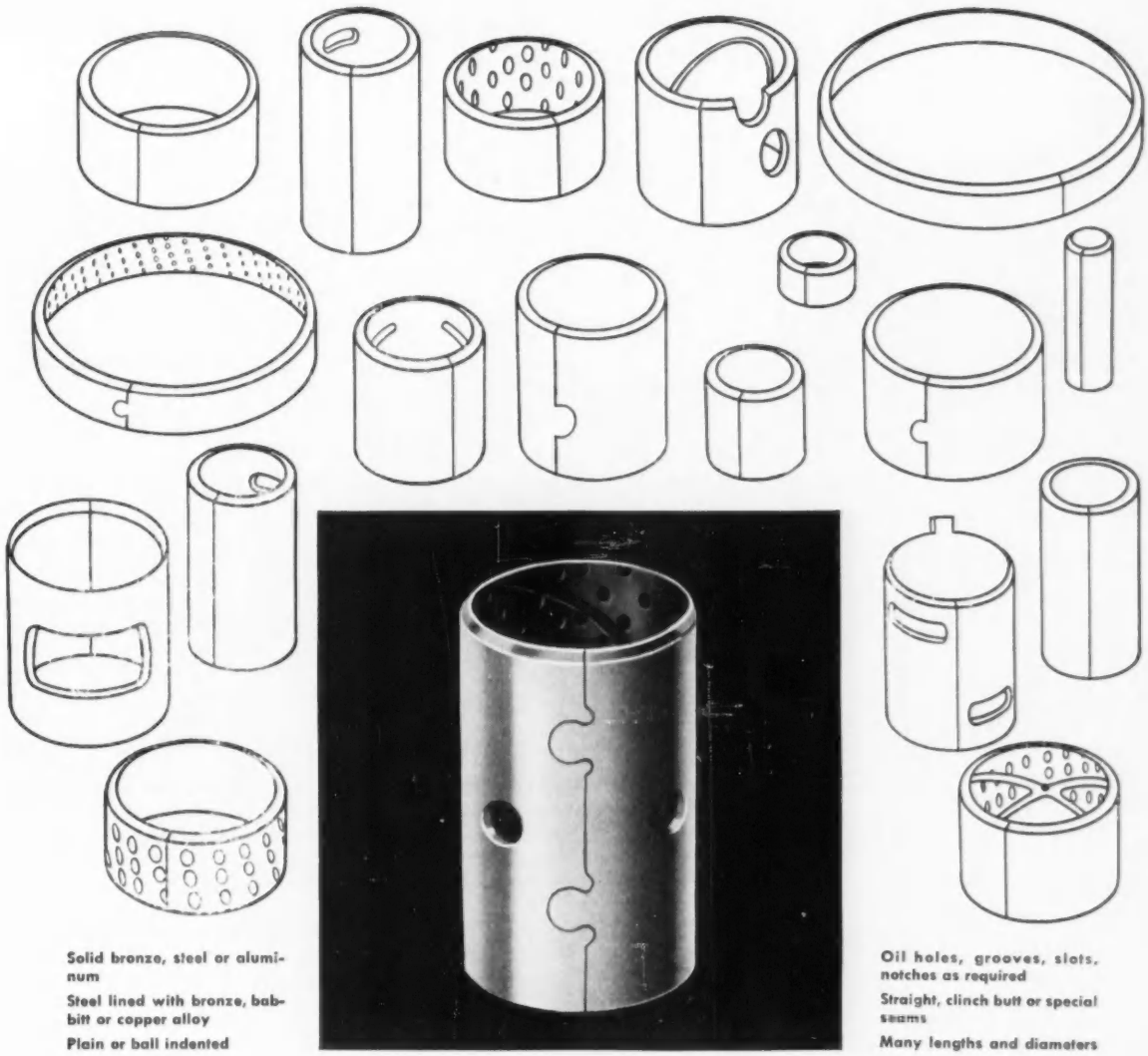
Single or Double-reduction Shaft-mounted Drive

Here is an all-steel drive available in a single reduction ratio of 5:1 and in two double-reduction ratios, 14:1 or 25:1. Ratings range from 2 hp at 5 rpm to 50 hp at 359 rpm; max torque rating at low-speed shaft is 31,000 lb-in.

A longer center distance between shafts allows using larger sheaves on installations where unit is mounted with input shaft toward driven machine or on through-shaft applications. Inspection covers on the three-wall, one-piece housing permit inspection of bearings and helical gears. An automotive-type dip stick is provided to check oil level quickly. This drive may be had by immediate delivery from stock. **Falk Corp., Dept. 255, 3001 W. Canal St., Milwaukee 1.**

For more information—
Circle 4, inside back cover

CONTINUED ON PAGE 104



Solid bronze, steel or aluminum

Steel lined with bronze, babbitt or copper alloy

Plain or ball indented

Oil holes, grooves, slots, notches as required

Straight, clinch butt or special seams

Many lengths and diameters

Bearing Performance • Bushing Economy plus special design features

Savings in materials, time and labor are possible using bimetal or plain rolled split bushings. Bimetal bushings provide bearing load-carrying qualities. All offer economy through volume production. Uniformity and strength are established through controlled alloy quality and grain structure. Our method of manufacture also permits wide flexibility in design features. Complete engineering service. For details, address:

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RESEARCH • DESIGN • METALLURGY • PRECISION MANUFACTURING

Meter-relay . . .

is available in a plug-in model, with a screw-down mount (solder connections), or for use with a nine-pin noval plug. Possible contact arrangements include: single-high, single-low, double-high-and-low, and also tandem contacts. Sensitivity rating is for any value between 0.2 microamp and 10 amp; 0.1 milliv to 500 v, dc or ac. Meter-relay is shown with hermetically sealed case. Dimensions: 1 x 1¼ x 1⅞ in. Delivery, 4 to 5 wk; price, $50 to $80, depending on sensitivity. **Assembly Products, Inc., P. O. Box XX, Palm Springs, Calif.**

For more information—
Circle 5, inside back cover

Two and Three-way Control Valves . . .

for equipment requiring high operating pressures provide fast response, leak-free operation and smooth, shockless opening and closing at max rated pressure. Sleeve-type construction, with valve bodies machined from solid aluminum-bronze bar stock. A replaceable, seal sleeve insert in the valve body aligns valve stem and seats; this insert is of hardened stainless steel. Available in ¼ through 2-in. NPT sizes for use with any applicable pneumatic or electropneumatic cycle control device, or for manual operation. Valve diaphragm is actuated by 35 to 40-psi air. Valves are normally open or normally closed, with fully balanced stems. **Sinclair-Collins Valve Co., 454 Morgan Ave., Akron 11, Ohio.**

For more information—
Circle 6, inside back cover

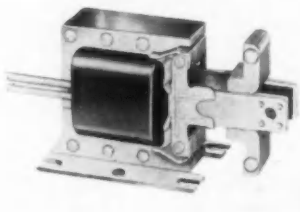
Industrial Solenoid Valves . . .

for general applications are designed to control flow of water, air, light oils, brines, low-pressure steam, industrial gas, liquefied petroleum gases, and many other non-corrosive fluids, with a max operating pressure differential of 150 psi. Can be mounted in any position. Valves have two moving parts and operate on the pilot-port principle. Synthetic diaphragms are said to be durable. **Controls Div., Jackes-Evans Mfg. Co., 4427 Geraldine Ave., St. Louis 15.**

For more information—
Circle 7, inside back cover

Encapsulated Solenoid Coil . . .

prohibits penetration by water, extreme humidity, oils, salt air, acid and alkaline solutions, ether, alcohol, hydraulics and other fluids. The No. 18, ac solenoid that utilizes this coil is applicable to equipment of any kind that must perform under intense moisture conditions.



Solenoid has high dielectric strength; resistance to abrasion, and thermal or mechanical shock. Units are available for intermittent or continuous duty. With ⅛-in. plunger stroke, it can lift up to 11 lb. Stroke is adjustable from 3/32 in. to 1 in. Units operating on dc are also available for 400-cps operation. **Guardian Electric Mfg. Co., 1621 W. Walnut St., Chicago 12.**

For more information—
Circle 8, inside back cover

Beryllium-copper Spring Pins . . .

in new sizes that extend the range from 0.062 in. through 0.500 in. dia are now offered. The slotted, chamfered, tubular spring pin has been heat-treated for max strength. It is nonmagnetic, corrosion-resistant and has good electrical conductivity. With dia slightly larger than hole into which it is to be inserted, it presses against the hole walls to prevent loosening under severe vibration. It can be inserted with hand tool or machine into normal production-drilled holes that require no special machining, taping or reaming. May be re-used. **Elastic Stop Nut Corp. of America, Union, N. J.**

For more information—
Circle 9, inside back cover

Two-way Solenoid Valve . . .

designed for tight shutoff on pressures to 1500 psi can be mounted in any position. The high-pressure valves are especially suited for hydraulic applications. Internal pilot-operated piston valves are either stainless steel or brass bar stock with Teflon disks and stainless steel magnetic parts. Normally closed operation only. For continuous or intermittent service in ¼ or ⅜-in. pipe connections, with general purpose watertight or explosion-proof enclosures. **Automatic Switch Co., Florham Park, N. J.**

For more information—
Circle 10, inside back cover

Gage Protector . . .

guards fluid pressure gages from excessive surge pressures. By isolating gage from system except when readings are taken, accuracy and reliability are maintained. The spring-loaded device is normally closed. When pushbutton is released, gage line automatically closes, cutting off gage from rest of the circuit. Simultaneously, a port opens to permit gage to be drained to reservoir. For pressures to 5000 psi, it can be used with any hy-

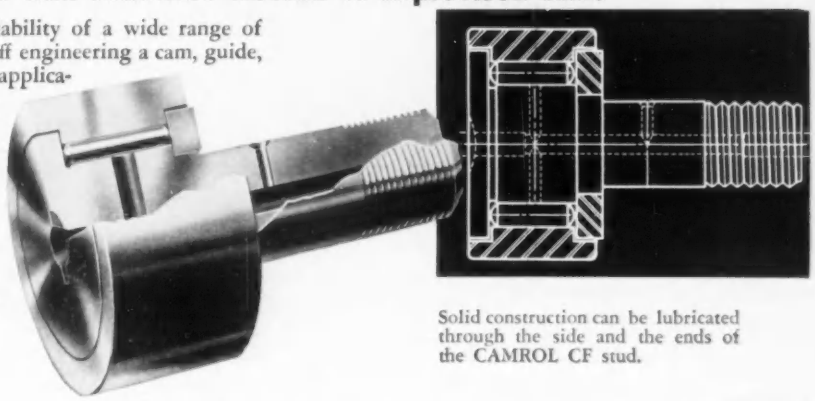
CONTINUED ON PAGE 106

BEARING TIPS by McGill

For convenience, with savings in time and cost

Use McGILL® CAMROL Cam Followers instead of improvised units

Simplification of design with availability of a wide range of standard bearings takes the strain off engineering a cam, guide, support or track roller bearing application. No need to "build up" a special unit when you can select the proper size standard CAMROL bearing engineered especially for the job. McGill's CAMROL bearing construction offers full type capacity, with provision for shock, in a compact precision unit. Specify CAMROL, the original cam follower, in either CF (with stud) or CYR (shaft mounting) series. Sealed and prelubricated bearing available also.



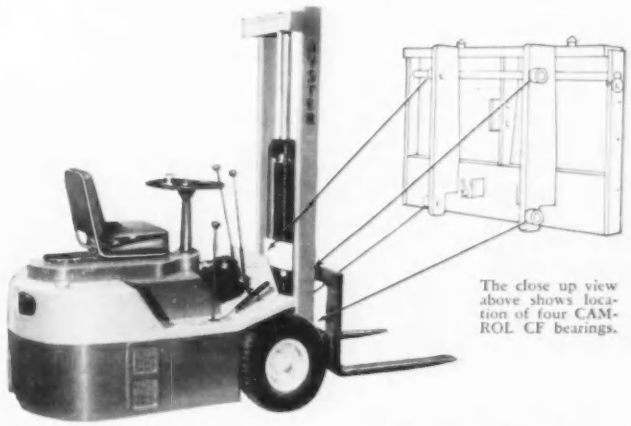
Solid construction can be lubricated through the side and the ends of the CAMROL CF stud.

YR bearings help F-100 Super Sabre make slower and safer landing

The supersonic speeds obtained by today's modern aircraft set up design problems not encountered with older, slower planes. The overall streamlined design required for speed in flight, for instance, necessitated finding ways of supporting the North American F-100 Super Sabre at low air speeds required for landing. A

series of slats on the leading edge of the wing, providing greater lift at lower air speed, was the answer. Each slat is supported by McGill CAMROL YR bearings — especially designed to permit shaft or yoke mounting. These long-life bearings carry the loads of these slats as they move on tracks during flight of the Supersonic F-100.

CAMROL® CF bearings out-perform friction rollers as fork support bearings



The close up view above shows location of four CAMROL CF bearings.

Small size and high load-carrying unit construction with simplified lubrication are among principal benefits obtained by Hyster Company from use of CAMROL CF bearings as fork support rollers in its Hyster 20 and other lift trucks.

Two bearings ride up and down inside each vertical mast section to position the lift truck fork under load. Speeds are relatively slow but the crushing loads on each bearing are heavy.

In this particular application, the exterior surfaces of the bearings are treated with a black oxide finish. This provides corrosion-resistance which serves to augment maintenance-free operation, a characteristic of CAMROL bearing construction.

Fact-packed Bearing Catalog

Write for your copy of Catalog 52-A, a revised, 128-page Bearing Selection Guide.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

draulic oil and many other fluids. Equipped with ¼-in. NPT ports, and holes for panel or bracket mounting. Can be installed in any position in any hydraulic circuit. $14.85 FOB Sarasota. **Sarasota Precision Products, Inc., 1314 N. Lime Ave., Sarasota, Fla.**

For more information—
Circle 11, inside back cover

Light-duty Caster . . .

in the 150-to-275-lb capacity range has a plated finish. Casters have hardened ball raceways, cold-formed steel yoke and top plate, and a permanent, squeezed rivet king pin. **Caster Div., Rapids-Standard Co., Inc., 342 Rapistan Bldg., Grand Rapids 2, Mich.**

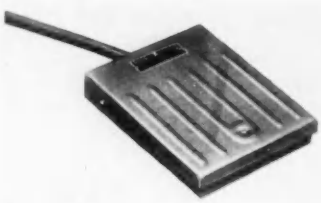
For more information—
Circle 12, inside back cover

Switch with Taper Pins . . .

is a nonsnap, normally open, momentary-contact SPST model for solderless wiring. Three female receptacles are provided with

a built-in short between two of them to accommodate in-and-out wiring with taper pins. The ⅜-in. 32-threaded mounting bushing and knurled nut are black anodized aluminum. Furnished with internal-toothed lock washer and choice of red or black button. **Grayhill, Inc., 561 Hillgrove Ave., LaGrange, Ill.**

For more information—
Circle 13, inside back cover



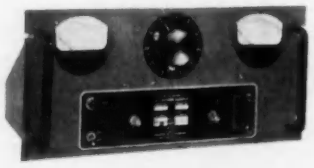
Footswitches . . .

in 12 variations are rated from 6 to 15 amp, UL-approved. Available with dust-proof switch mechanism, or silent actuating switch if desired. Size is 2¾ x 3½ x ⅞ in. high. A dual version is also offered. Designed for business machines, recording equipment, tape dispensing machines, heat sealing machines and photographic equipment. **Vemaline Products Co., P. O. Box 222, Hawthorne, N. J.**

For more information—
Circle 14, inside back cover

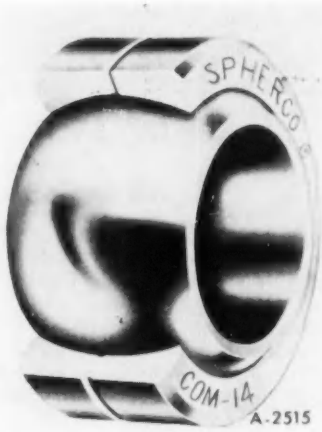
Power Supply for Dc . . .

has continuous duty rating of 0 to 150 v dc at 2 amp. Voltage regulation is held to 1%, ripple to less than 0.03% of average current at max output. Tubeless unit occupies 8¾ in. of panel height; extends 9 in. behind panel. Controls include power switch, pilot light, indicating line and load fuses, a 4½-in., 2%-accurate dc voltmeter and ammeter, and pair of five-way, insulated binding posts. Additional pair



of output terminals are at rear of chassis. **Opad Electric Co., 69 Murray St., New York 7.**

For more information—
Circle 15, inside back cover



Spherical Bearings . . .

in standard series for static load ratings from 2,700 to 104,000 lb, and in commercial series with static load capacities from 3,250 to 54,700 lb are now available. Standard bearings are offered in five series that cover the radial static-load ratings. Outer race materials are aluminum-bronze, cadmium-plated; heat-treated alloy steel, cadmium-plated; heat-treated alloy, cadmium-plated; carbon steel, cadmium-plated or heat-treated stainless steel. Used throughout series are 52,100 steel-hardened balls plated with hard chrome. The commercial series, comprised of a low-carbon steel outer race and a hardened-steel ball, is offered in 11 sizes. **Spherco, Sealmaster Bearing Div., Stephens-Adamson Mfg. Co., Ridgeway Ave., Aurora, Ill.**

For more information—
Circle 16, inside back cover

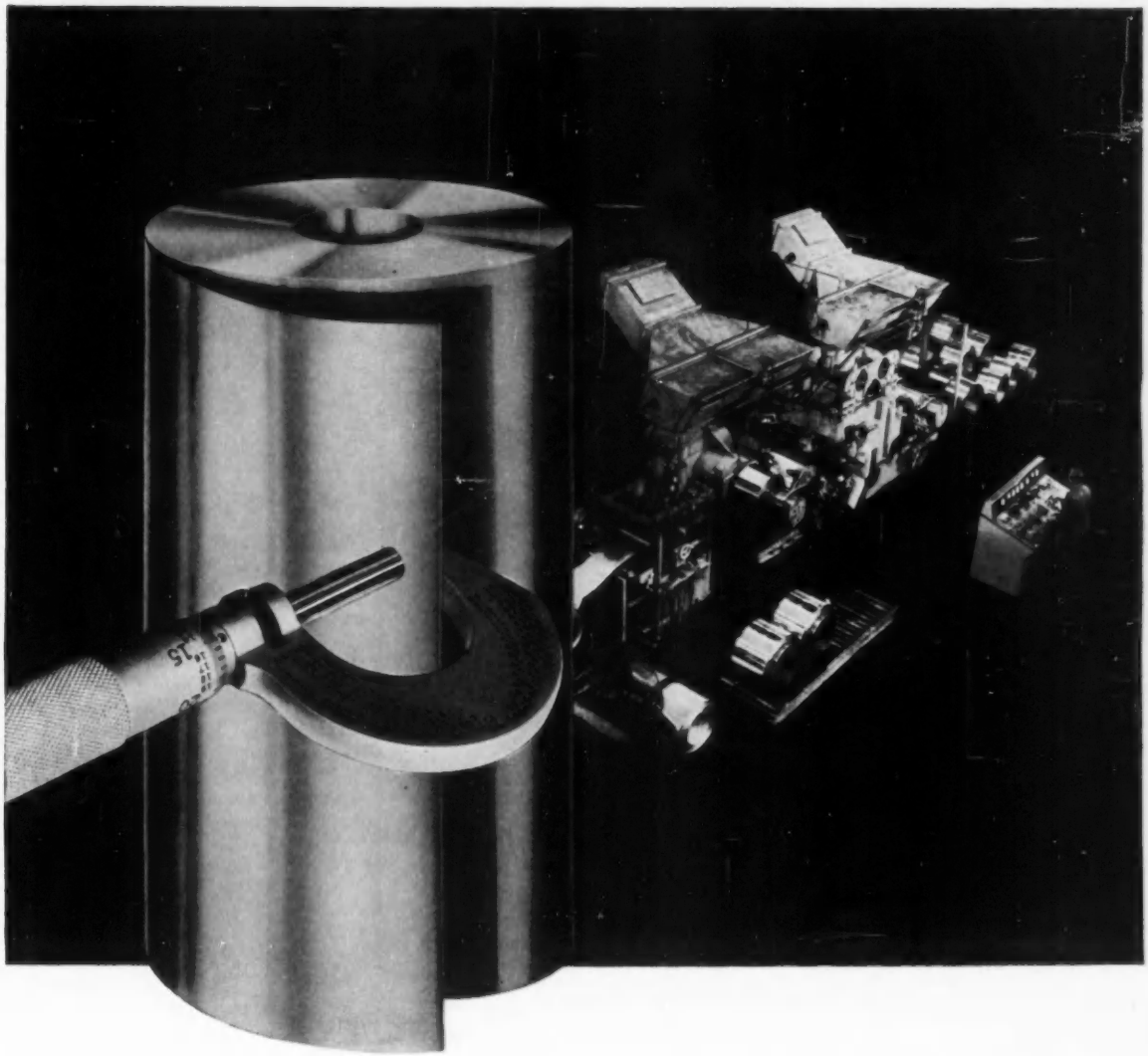
Diaphragm Seals . . .

made of nylon, Dacron and glass fiber are coated with silicones and other elastomers. Seals allow transformation of fluid pres-

CONTINUED ON PAGE 108

When Brass Strip Tolerances Call For

PERFECTION TO THE "Nth" DEGREE



Possibly, you've never seen—or even heard of—a Sendzimir Rolling Mill like the one pictured above. Not many people have. But if you use close-tolerance brass, copper or bronze strip, you'll certainly appreciate what these high-speed, precision units can do when you order Bridgeport Sendzimir-Rolled Strip.

These mills—now in operation at Bridgeport's plants—are capable of rolling light-gauge strip into economical, long-length coils to meet the most rigid gauge tolerances.

Bridgeport Sendzimir-Rolled Strip has other advantages as well. It has remarkable uniformity of gauge and mechanical properties from edge to edge and end to end. It also has a beautiful luster—all properties you can use to advantage in your own production.

Get details on Bridgeport Sendzimir-Rolled Strip today. Our nearest Sales Office is ready to give you complete information.

matched
Bridgeport **Brass Alloys**
to your job

BRIDGEPORT BRASS

Offices in Principal Cities • Conveniently Located Warehouses
Bridgeport Brass Company, Bridgeport 2, Connecticut
In Canada: Noranda Copper and Brass Limited, Montreal

Simple Design Changes Permit
STANDARD RIVETS
to Replace Costly "Specials"

We produce a wide variety of special fasteners for our customers . . . but only when we *have to!* Only when a *standard* rivet just won't fit the application. We bring our experience, skill and engineering know-how to every job, large or small. It's a challenge to see if we can't modify designs to substitute an inexpensive "standard" rivet for a more costly "special".

To improve product appearance and strength
. . . to take full advantage of automatic assembly
. . . to cut delivery time and production costs
—get in touch with Milford first!

THE MILFORD RIVET

MILFORD RIVET & MACHINE CO.
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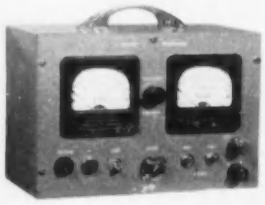
sure energy into movement. They are described as nearly friction-free, without characteristic running friction or breakaway resistance. Diaphragms seal effectively at temperatures from —65 to 500 F in a variety of fluids. Available with bore dimensions to 12 in., with a convolution drawn to depths of 4 in., and in thicknesses of 0.010 in., 0.013 in., and 0.018 in. **Stillman Rubber Co., 5811 Marilyn Ave., Culver City, Calif.**

For more information—
Circle 17, inside back cover



Transistorized Power Supplies . . .

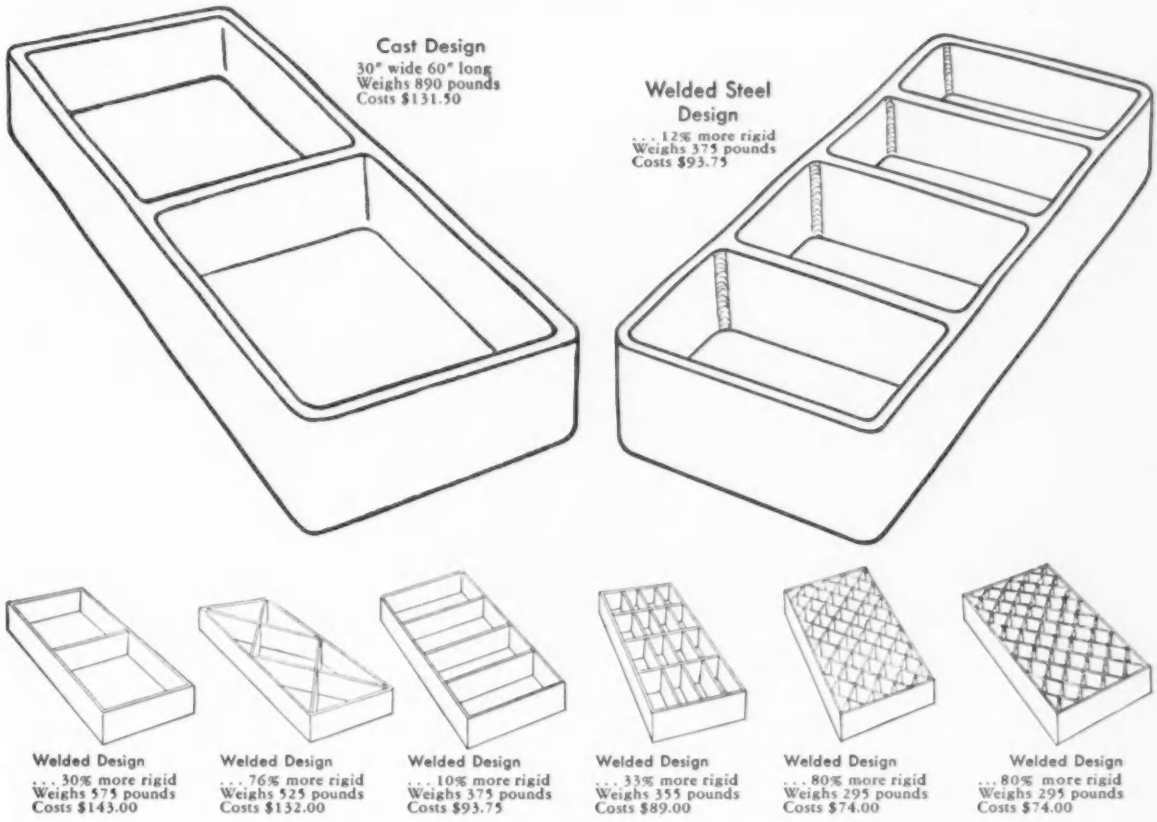
for 60 or 400-cps operation are semi-variable with nominal voltages from 6 to 50 v and full-load current ratings from 50 to 500 ma. Ripple and regulation factors are better than 0.5%; temperature range of operation is from —30 to 65 C. Units have passed shock and vibration tests. Suitable for labs, for use with various types of instrumentation, and in special packaging for industry. **Electronic Assembly Co., Inc., 5 Prescott St., Boston 19.**

For more information—
Circle 18, inside back cover

Gray Rubber Wheel . . .

is nonmarking and available on plate and stem swivel, and on stationary casters. Designed in light, medium and heavy-duty

(Continued on page 112)



How to Increase Rigidity of Machine Bases

. . . while cutting weight and cost

Machine base (A) made from gray iron used 1⅛" thick sections, weighs 890 pounds.

Machine base (B) designed for welded steel needs only 7/16" sections, yet is 1.12 times more rigid. Since smaller sections are used, base (B) requires only 375 pounds of material. Based on the fact that steel costs less than iron, and less steel is used—material savings are $51.50.

The smaller drawings show variations of this machine base with rigidity and price as compared to the cast design.

By taking advantage of the stronger, more rigid properties of steel, additional savings in material cost can be made as shown to further reduce over-all costs of production.

Designers!

Ask your Lincoln representative how you apply these potential savings to your designs. Available also: New Procedure Handbook of Arc Welding Design & Practice at slight cost; Machine Design Sheets and Design Courses at Lincoln Electric main plant. Write

THE LINCOLN ELECTRIC COMPANY

Dept. 1324 • Cleveland 17, Ohio

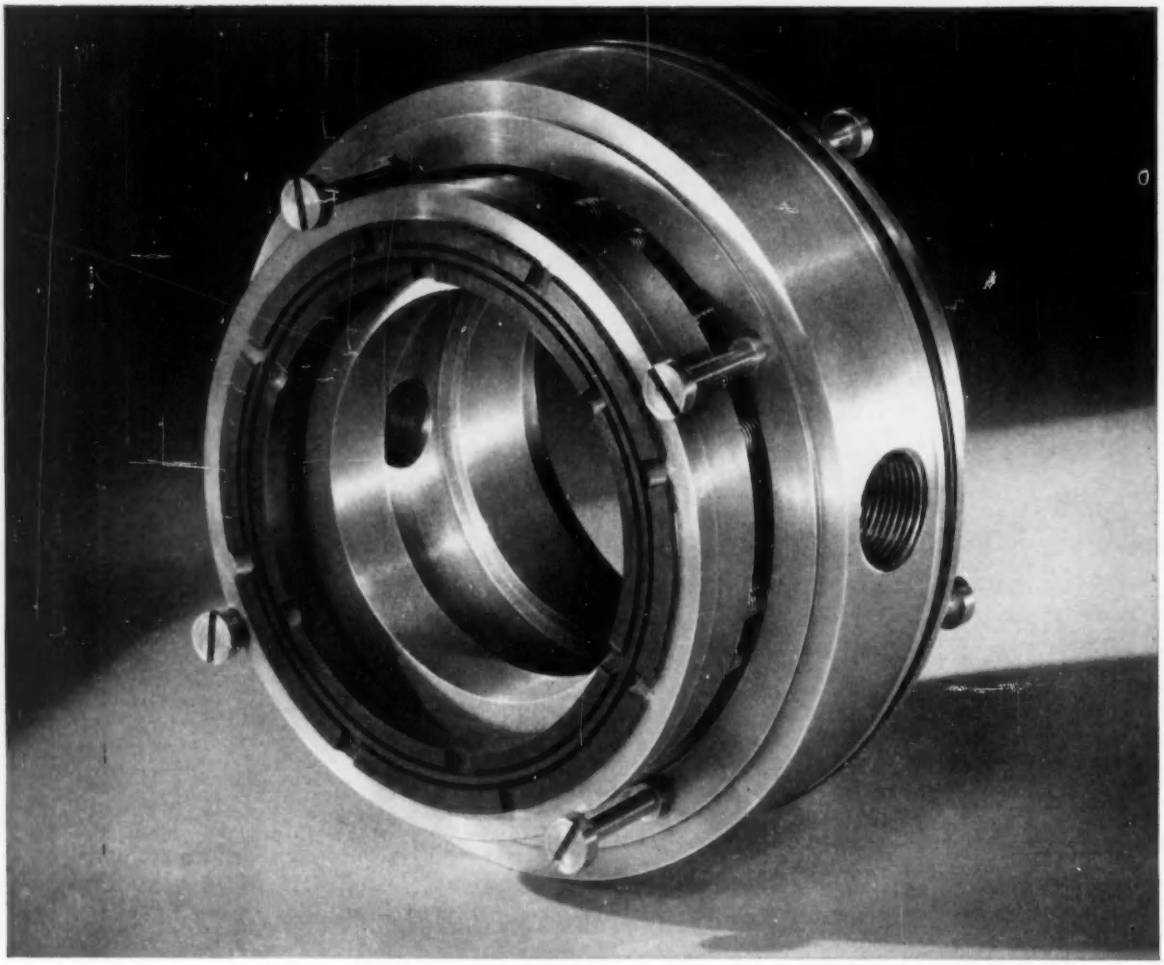
The World's Largest Manufacturer of Arc Welding Equipment

When steel is 3 times stronger

Has 2½ times the rigidity

Yet costs a third as much

WHY use anything but welded designs?



Koppers Face Type Seal Provides Up to 20,000 Hours of Service!

Up to 30,000 Hours in Laboratory Tests Using Clean Gas!

Koppers engineering has created an unmatched sealing surface that gives Koppers Face Type Seals a much longer-than-ordinary service life.

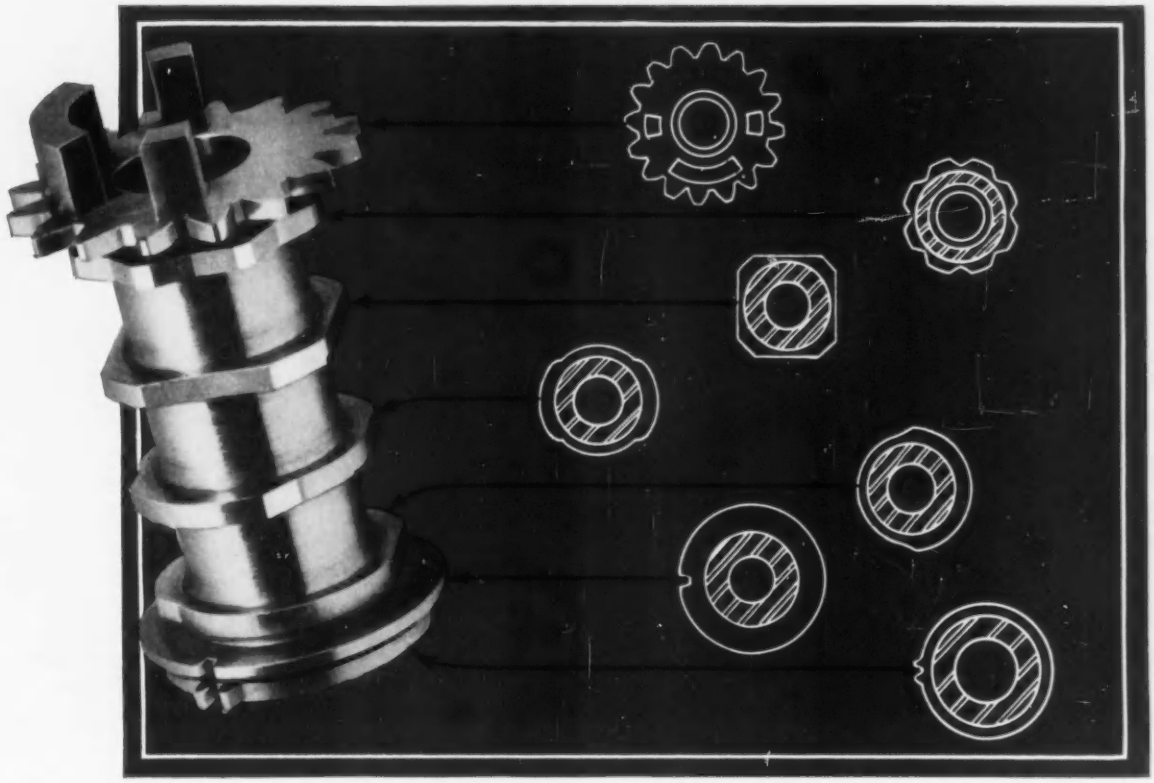
The exclusive design of the sealing surface keeps pressure distribution and hydraulic balance unchanged during operation . . . permits a light face loading which lowers interface temperatures. Hydraulic balance allows sealing of gases and liquids through a wide range of rubbing speeds. Rugged construction adds to Koppers long service life. Rotating collars can be of hardenable stainless steels, cutlery and die steels, Stellites, or of a hard chromium or carbide face. Ring is of carefully selected grades of carbon.

If you have a sealing or piston ring problem, Koppers entire research, production and engineering facilities are at your disposal. For more details, write to the KOPPERS COMPANY, INC., 7310 Hamburg St., Baltimore 3, Maryland.

Koppers Company, Inc.
Metal Products Division
Piston Ring and Seal Dept.
***Engineered* Products**
Sold with *Service*

KOPPERS®

MECHANICAL SHAFT SEALS



DESIGN for Lower Cost

In many instances, designing for production on a Fellows Gear Shaper offers exceptional opportunities to lower costs, on non-involute shapes as well as gears. This is particularly true where gear shaper versatility makes it possible to generate multiple parts on the same shaft, thus eliminating assembly operations and simplifying design.

The unusual multiple cam and gear part shown is an example. The gear and various cams are positioned to within 0.001" alignment. Since there were no keyways or other machining required for assembly, there was a considerable reduction in production time, in addition to the time saved because of the high cutting speed of the gear shaper. Finally, the integral design resulted in a saving in weight without loss of strength.

These and other advantages of the method are described and illustrated in the booklet, "The Art of Generating with a Reciprocating Tool." This booklet, although not new, contains a lot of information that is valuable to designers concerned with generated shapes. Since 1951 we have distributed over 10,000 copies. If you would like one, just write us.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices: 1048 North Woodward Ave., Royal Oak, Michigan
150 West Pleasant Ave., Maywood, N. J.
5835 West North Ave., Chicago 39
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Patented Metal-Cals give your product the permanency of anodized and dyed aluminum foil. No fastening devices or supporting background is required so dress up your product for that "extra sales appeal."

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417 East Beach Avenue · Inglewood 3, California

U.S. Pat. 2,769,265

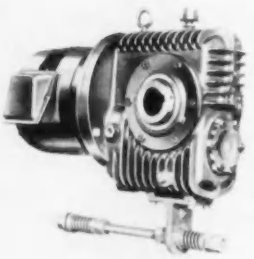
sizes, 2½ in. through 10 in. Caster wheel has iridite-coated zinc plating on horns, noise-deadening swivel race lubricant, and 4-in. swivel horn with molded, solid-rubber wheels. **Gleason Caster Div., 250 Dept. A, N. 12th St., Milwaukee 3.**

For more information—
Circle 19, inside back cover

Detachable Fitting . . .

for seamless metal hose is designed to simplify and expedite maintenance. Consists a solid, one-piece ferrule and metal-to-metal seat. Specially-formed concentric grooves and ridges in the internal flat seat of the end connector make it unnecessary to smooth, file or grind the flat end of the flexible tubing. No gaskets or packing rings are required. Standard male fittings for seamless tubing from ¼-in. ID to 1-in. ID are available in standard pipe sizes from ¼ in. to 1-in. NPT, inclusive. **Seamlex Co., Inc., 41-23 24th St., Long Island City, N. Y.**

For more information—
Circle 20, inside back coverd



Hollow Shaft Gear Motors . . .

take advantage of the high load capacity in small center distances of double-enveloping worm gearing. By combining this worm gearing with a helical primary, the new gear motors provide high-output torque ratings, compact housing, and cost below that of comparable competitive units. Hollow shaft mounting permits driving shafts in any position with a floating power unit. Available to handle 1- to

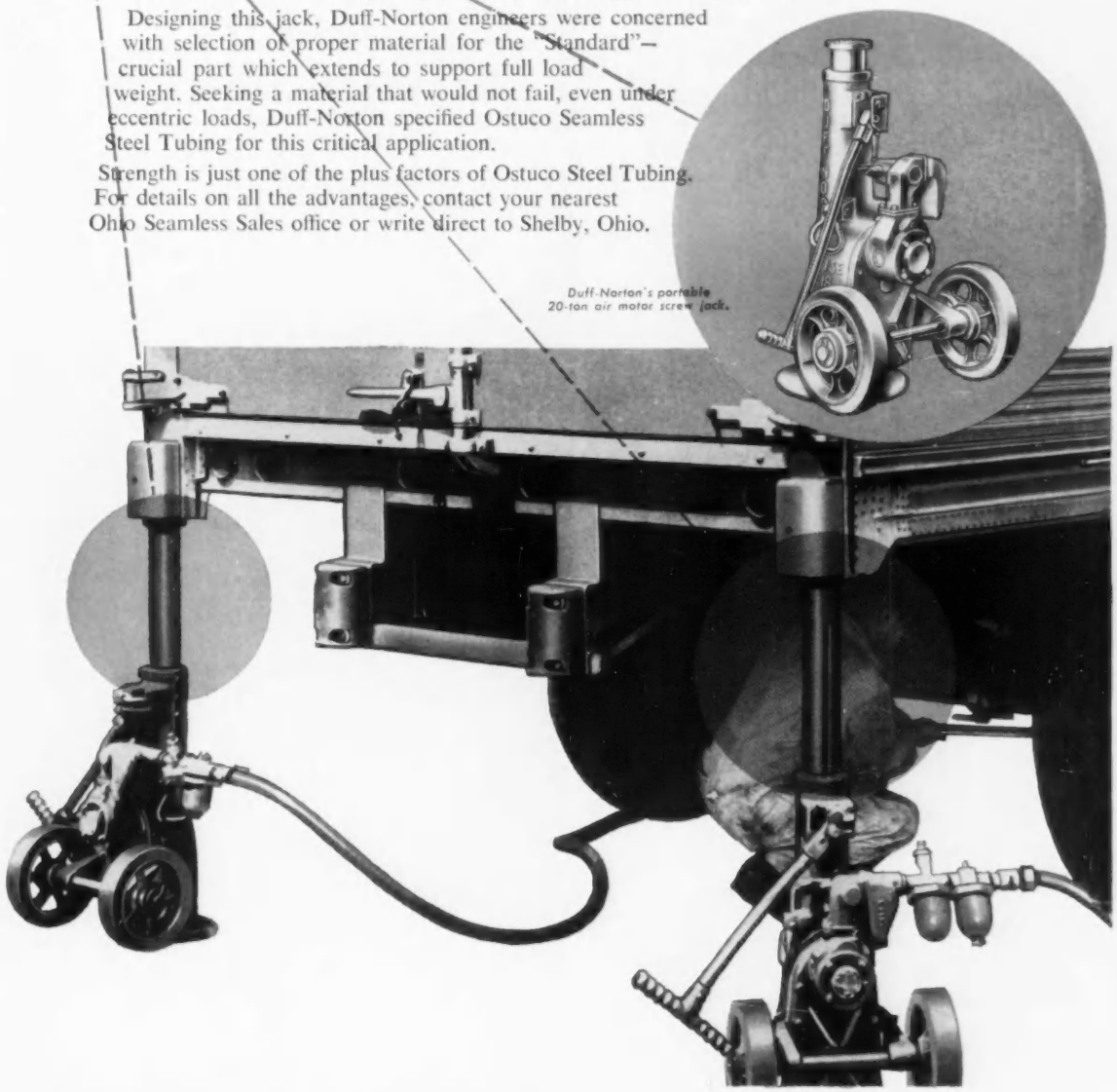
(Continued on page 116)

STRENGTH PROBLEM SOLVED with Ostuco Steel Tubing

Duff-Norton Company, Pittsburgh, manufactures a portable 20-ton air motor screw jack now finding wide acceptance as a maintenance tool by the trucking industry because of its versatility, dependability, and rugged strength.

Designing this jack, Duff-Norton engineers were concerned with selection of proper material for the "Standard"—crucial part which extends to support full load weight. Seeking a material that would not fail, even under eccentric loads, Duff-Norton specified Ostuco Seamless Steel Tubing for this critical application.

Strength is just one of the plus factors of Ostuco Steel Tubing. For details on all the advantages, contact your nearest Ohio Seamless Sales office or write direct to Shelby, Ohio.



Duff-Norton's portable 20-ton air motor screw jack.

OSTUCO TUBING

MANUFACTURED IN **SHELBY, OHIO**

EXCLUSIVELY BY

OHIO SEAMLESS TUBE DIVISION

OF COPPERWELD STEEL COMPANY

SHELBY, OHIO • Birthplace of the Seamless Steel Tube Industry in America

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CANADA: Railway & Power Engr. Corp., Ltd.

EXPORT: COPPERWELD STEEL INTERNATIONAL COMPANY, 225 Broadway, New York 7, New York

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IMAGINE WHAT YOU CAN DO

with a material as versatile as this

- Strong and durable in thin sections.
- Light weight (one-half the weight of aluminum).
- Easily formed, punched, corrugated and cold embossed.
- Resists hard blows and abrasion—cannot rust or corrode.
- Bonds well with adhesives—can be riveted, stapled, stitched.
- Will take paint, varnish, lacquer or vinyl finish.
- Can be colored in manufacture in production quantities.
- Chemically inert, has no odor and absorbs no odor.
- Can be combined with metallic and non-metallic materials.
- Has low thermal conductivity and good dielectric strength.
- Available in sheet, rod and tube forms.

The virtues of National Vulcanized Fibre—a cellulosic plastic—don't end here. They may give you the answer to your current design problem.

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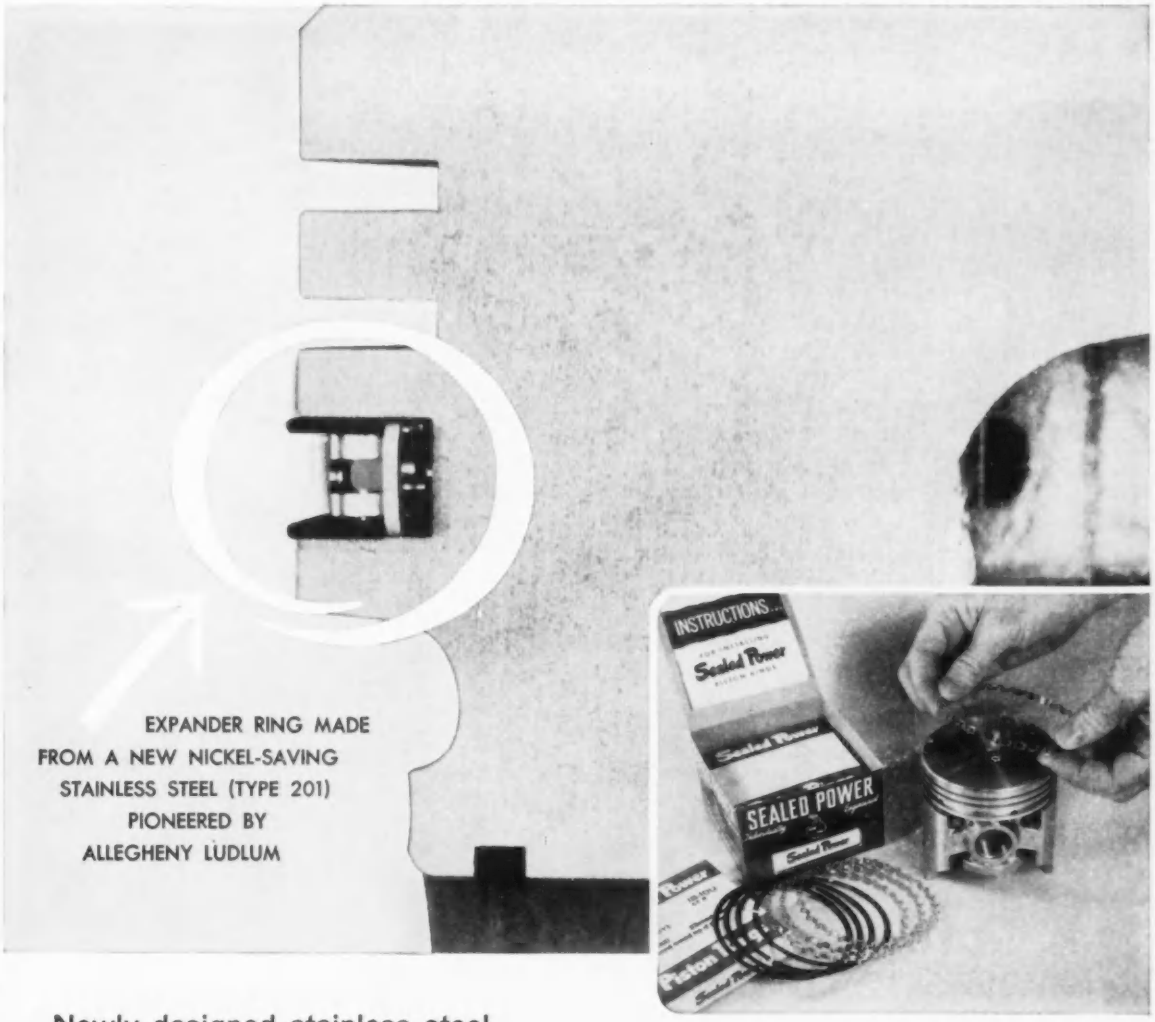
Write today for technical data and a personal set of samples of this unique material. A brief note on your letterhead will bring them without delay. Address Dept. H-10.



Newly-designed stainless steel

OIL RING ASSEMBLY gives auto drivers 3-WAY ADVANTAGE

BETTER OIL ECONOMY

BETTER ENGINE PROTECTION

LONGER ENGINE LIFE

Oil rings do a very demanding job in an automobile engine. They control the amount of lubricant allowed to pass up to the compression rings and cylinder walls. In modern cars, with higher compression ratios, the tension of the oil ring expanders has had to be increased—and that's where Allegheny Type 201 stainless offers advantages.

Engine operating temperatures have virtually no effect on this new stainless alloy. It maintains constant tension whether the engine is hot or cold, permitting most efficient design for maximum flow of lubricant when friction is greatest, and less flow when the engine is warmed up and requires less. Formerly, carbon steel expander rings suffered a tension drop when heated to engine operating temperature. Then under heat they took a permanent set, which caused the loss of "cold tension." Allegheny 201 also has ended the problem of expander breakage due to the corrosive action of engine deposits.

This success story is just one of many being written with the new 200-series of low-nickel Allegheny Stainless Steels. Fabricating methods are virtually the same as with the higher-nickel 300-series, but you'll find some advantage in cost, and much greater availability in times of nickel shortage. • If these new steels seem to fit into your manufacturing or service picture, give us a call. *Allegheny Ludlum Steel Corporation, Oliver Bldg., Pittsburgh 22, Pa.* WGW 6926

WRITE for a copy of our "Technical Horizons" bulletin on the Allegheny 200-Series stainless steels.

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Make it BETTER—and LONGER LASTING—with

Allegheny Stainless

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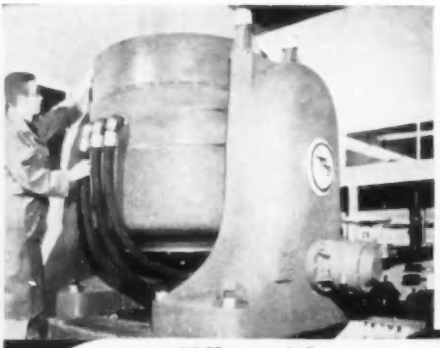
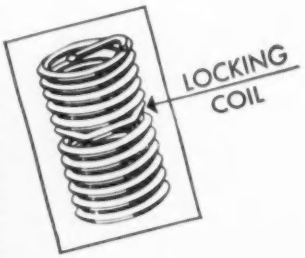
Warehouse stocks carried by all Ryerson steel plants





Why this CRITICAL VIBRATION TEST EQUIPMENT Uses *HELI-COIL** Screw-LOCK Inserts —to Hold Parts Securely Under Extreme Shock & Vibration

*Reg. U.S. Pat. Off.

Currently the world's highest force electro-dynamic vibration exciter, the MB Model C250, made by the MB Manufacturing Co., is vital to government research in today's air age... has a frequency range of 2-500 cps., and a total force output of 25,000 lbs. It can be adapted to operate in chambers where temperatures range from −100°F to 300°F and simulated altitudes hit 125,000 feet.

Test specimens of up to 2190 lbs., subjected to accelerations of 10 g., must be securely held to the unit's moving assembly.

The thread assemblies within the vibrator, and joining test specimens to the unit, are subjected to grueling shock and vibration. Yet, even under these extreme conditions, ***Heli-Coil*** Screw-LOCK Inserts (277 of them) function perfectly... protect threads against stripping... hold fasteners securely.

Meeting military specifications for torque and vibration, this new, one-piece stainless steel Screw-LOCK Insert:

1. positively locks screws against loosening under impact and vibration
2. prevents thread wear, stripping, corrosion, galling, seizing
3. eliminates the need for lock-nuts, lock-wiring, and other supplementary locking devices
4. offers high re-usability on repeated disassembly and reassembly.

Heli-Coil Screw-LOCK Inserts are available in many sizes, including the new miniature 4-40. For further information, write 4227

HELI-COIL CORPORATION
A Division of Topp Industries, Inc.

HELI-COIL CORPORATION
610 Shelter Rock Lane, Danbury, Conn.

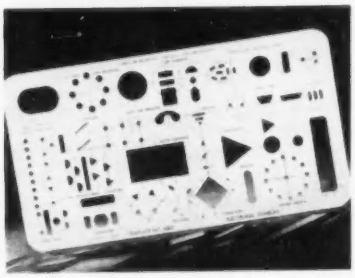
☐ Send me complete design data on ***Heli-Coil*** Screw-LOCK Inserts.
☐ Who is my local ***Heli-Coil*** Applications Engineer?

NAME_____ TITLE_____
FIRM_____
ADDRESS_____
CITY_____ ZONE____ STATE_____

IN CANADA: W. R. WATKINS CO., LTD., 41 Kipling Ave. S., Toronto 18, Ont.

15-hp standard NEMA D-flange motors Can be ordered with or without motors. Output speeds range from 7.3 rpm to 525 rpm in 27 increments with 1750-rpm motors. **Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12.**

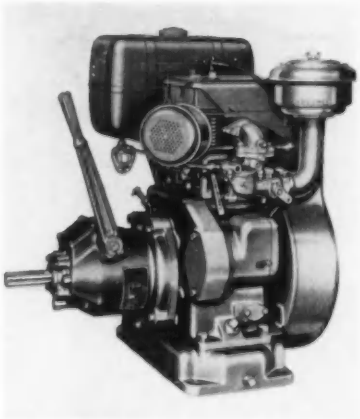
For more information—
Circle 21, inside back cover



Schematic Circuit Diagrammer . . .

for electronic circuitry covers the revised military standards and American standards specifications. Among symbols included are transistor diodes, tubes, plugs, relays, jacks, switches, resistors, inductors, amplifiers. The templets are made from matte-finished vinyl and printed in matte inks. Price is $3.50. **A. Lawrence Karp, 16 Putnam Park, Greenwich, Conn.**

For more information—
Circle 22, inside back cover



Sinlgle-cylinder 4-cycle Engine . . .

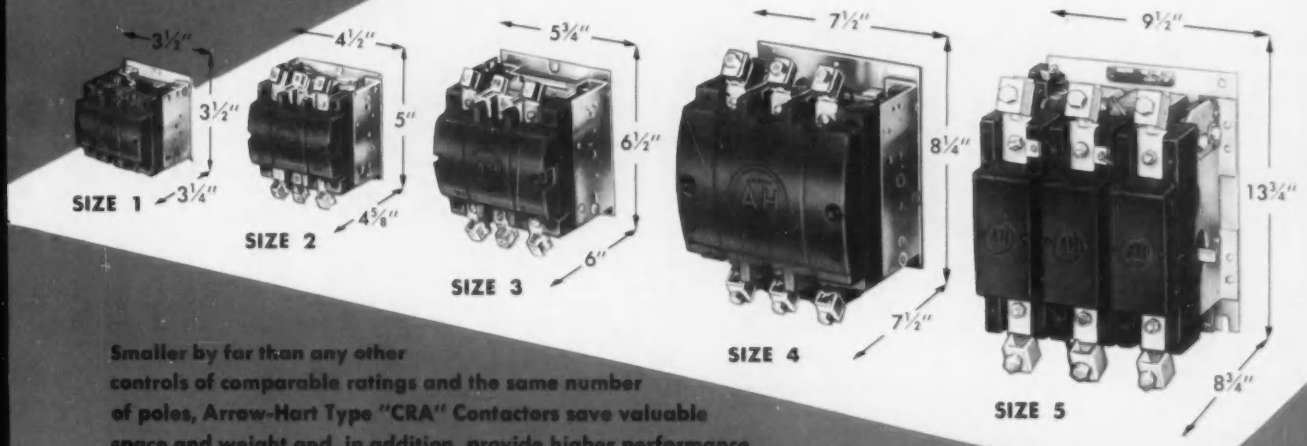
is rated at 12½ hp, has a speed range of 1600 to 3200 rpm, and piston displacement of 38.5 cu in. High torque of the motor provides load-holding lugging power that resists slowdowns under sudden shock loads, prevents stalling, and permits a

(Continued on page 119)

ARROW AH HART

POWER CONTACTORS

give you FINER PERFORMANCE in HALF the size



Smaller by far than any other controls of comparable ratings and the same number of poles, Arrow-Hart Type "CRA" Contactors save valuable space and weight and, in addition, provide higher performance standards with greater dependability, longer life and faster, easier installation and maintenance. Available in a complete line — from Size 0 to Size 5 — they provide the right control for all your requirements.

CONSTRUCTION FEATURES - -

Straight-Thru Wiring is quickly, easily accessible from the *front*. Double break contacts, of silver cadmium oxide for weld resistance on high inrush currents, are accessible from the front for fast, simple inspection or replacement. Molded AC operating coils resist moisture and dirt . . . normally last the life of the relay itself. Resinox base and hood provide maximum arc and tracking resistance.

OPERATING FEATURES - -

Magnets are designed for high-efficiency, low wattage operation. Exclusive mechanical design – available only on Arrow-Hart Controls – has proved its ability to operate dependably under the most adverse conditions.

EXTRAS AVAILABLE - -

If required, Arrow-Hart Type "CRA" Contactors can be supplied with: NEMA Type I, IV, VII, IX & XII Enclosures. Sizes 0, 1 & 2 can be supplied with coils & magnets for up to 250 volts DC.

"CRA" SELECTOR GUIDE

"CRA" UNIT	POLES	AUXILIARY HOLDING SWITCH	CONTINUOUS RATINGS IN AMPERES	EXTRA AUXILIARY SWITCHES
Size 0	2-5, N.O.	Optional	18	Yes
Size 1	2-5, N.O.	Optional	27	Yes
Size 2	2-5, N.O.	Yes	45	Yes
Size 3	2-5, N.O.	Yes	90	Yes
Size 4	2-5, N.O.	Yes	135	Yes
Size 5	3-5, N.O.	Yes	270	Yes

RESISTIVE HEATING LOADS (KW)

"CRA" UNIT		A-C VOLTAGE			
SIZE	PHASE	115	230	440	550
1	1	2.5	5	10	12.5
	3	4	8	17	21
2	1	5	10	20	25
	3	8.5	17	34	43
3	1	10	20	40	50
	3	17	34	68	86
4	1	15	30	60	75
	3	26	52	105	130
5	1	30	60	120	150
	3	52	105	210	260

HORSEPOWER RATINGS

"CRA" UNIT		A-C VOLTAGE		
SIZE	PHASE	110	220	440/550
0	1	1	2	3
	3	2	3	5
1	1	2	3	5
	3	3	7½	10
2	1	3	7½	10
	3	7½	15	25
3	1	7½	15	25
	3	15	30	50
4	3	25	50	100
5	3		100	200

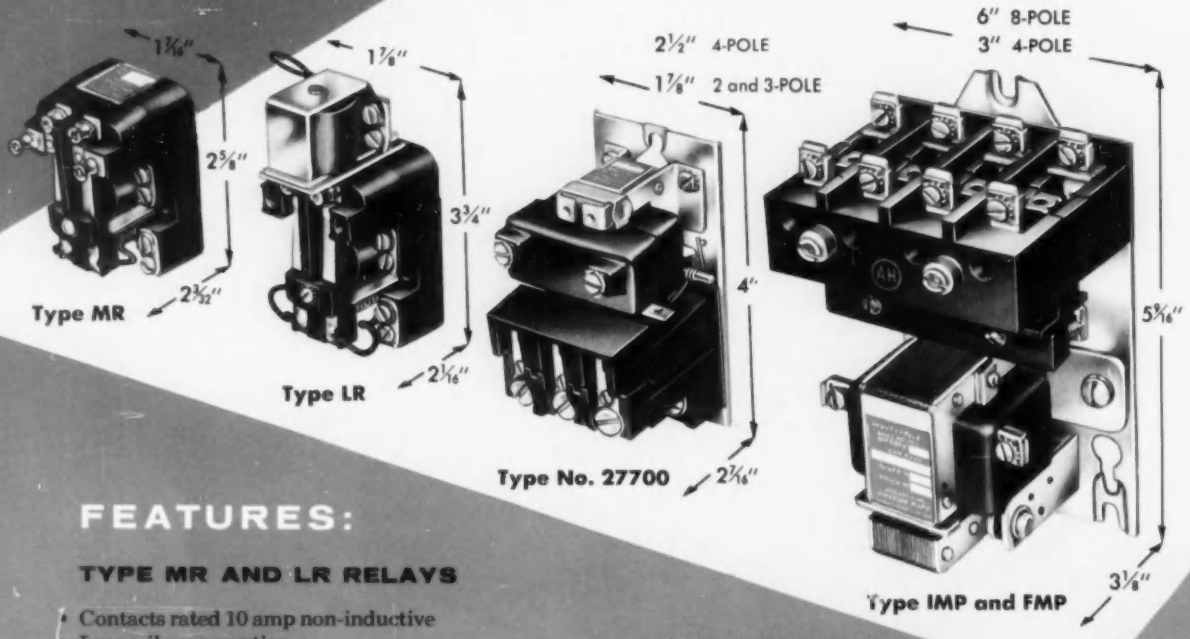
PLEASE TURN THE PAGE FOR ADDITIONAL INFORMATION . . .

ARROW AH HART

RELAYS

have EVERY feature you want --

LONG LIFE, ADVANCED DESIGN, VERSATILITY



FEATURES:

TYPE MR AND LR RELAYS

- Contacts rated 10 amp non-inductive
- Low coil consumption
- Contacts have wipe action
- A, B and C type contacts available
- Available 1 to 4 poles
- Coils available in all common A.C. or D.C. voltages
- Exceptionally long life
- Type LR – Latch-in or Latch-out or both

HEAVY DUTY RELAY, Type 27700

- Ideal for the new, heavy duty commercial appliances
- 20 amps per pole at 300V A.C.
- 120 amps interrupting capacity
- Coil inrush 12 watts (Approx.)
- Coil sealed 2.5 watts (Approx.)
- Available 2, 3 or 4 poles A.C.

TYPE IMP AND FMP

- Size 00 and 0 for operation to 600V A.C. or 250V D.C.
- Available with 2, 3, 4, 6 or 8 poles
- Instant interchangeability of contacts – no disassembly or reassembly of contacts
- Plug-in receptacle available for all sizes
- Latch attachment can be added by user
- Latch is convertible to latch-in or out or both
- Same coil and magnet regardless of number of poles

USE THIS COUPON TO SEND FOR COMPLETE INFORMATION ON ARROW-HART RELAYS AND POWER CONNECTORS

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THE ARROW-HART & HEGEMAN ELECTRIC COMPANY

103 Hawthorn Street, Hartford 6, Connecticut • Motor Control Division

Please send me complete engineering data on:

☐ Type "MR" and "LR" Relays ☐ Type "IMP" and "FMP" Relays
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Branch Offices and Sales Engineers Throughout the United States.

quick power recovery. Scheduled for early fall delivery. **Wisconsin Motor Corp., Milwaukee 46.**

For more information—
Circle 23, inside back cover

Brass Needle Valves . . .

suitable for air and liquid applications to 600 psi, for use as shut-off or throttling valves are now available from stock in all combinations of $\frac{1}{8}$ and $\frac{1}{4}$-in. male and female pipe ports and in $\frac{3}{8}$-in. male pipe ports. Valves are machined entirely from brass bar stock. Over-all length is $1\frac{5}{8}$ in. Gasket between bonnet and body is eliminated with a tapered metal-to-metal seat. **General Engineering Co., 260 S. 20 St., Newark, N. J.**

For more information—
Circle 24, inside back cover

Cap and Set Screw . . .

are now available in sizes 0 to 4 with a self-locking device offered previously on larger-sized fasteners. Microsize units are now standard catalog items. The tiny fasteners are particularly applicable where vibration causes loosening. The locking device consists of a small nylon pellet seated in a hole drilled into the threaded portion of the fastener. This compresses when the fastener is threaded into a tapped hole or nut, exerting an outward pressure that forces mating threads together more tightly. Resiliency is unaffected in temperatures from 70 F to 300 F. Made to Class 3A thread fit. In alloy or stainless steel. **Standard Pressed Steel Co., Jenkintown, Penn.**

For more information—
Circle 25, inside back cover

Diaphragm Spray Nozzles . . .

are equipped with manually operated shut-off assemblies to provide independent control of each nozzle in manifold installations. Construction consists of a di-

(Continued on page 122)

Prove by comparison tests that Parker O-rings seal better, last longer

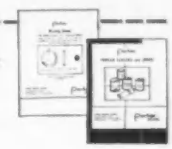
Comparison tests will prove it. You can't *see* the difference. You can't *feel* it. But in *use*, Parker O-rings seal better, last longer.

Why? Because Parker O-rings are precision-molded of superior compounds developed by exhaustive research and experimentation. Our engineering service will help with your problems — whether in gland design or compound. From Parker, you get the *right* O-ring for your *specific* application.

These trouble-free, leakproof seals are carefully evaluated for elongation, tensile strength, compression set ratings, resistance to oils, fuels, chemicals and temperature extremes. Exacting laboratory and service tests make sure that Parker O-rings meet applicable specifications. Whatever your requirements, Parker can supply the O-rings you need.

Parker
Hydraulic and fluid system components

Parker O-Lube is especially formulated for O-ring lubrication requirements. It comes in a handy, squeeze-tube container.

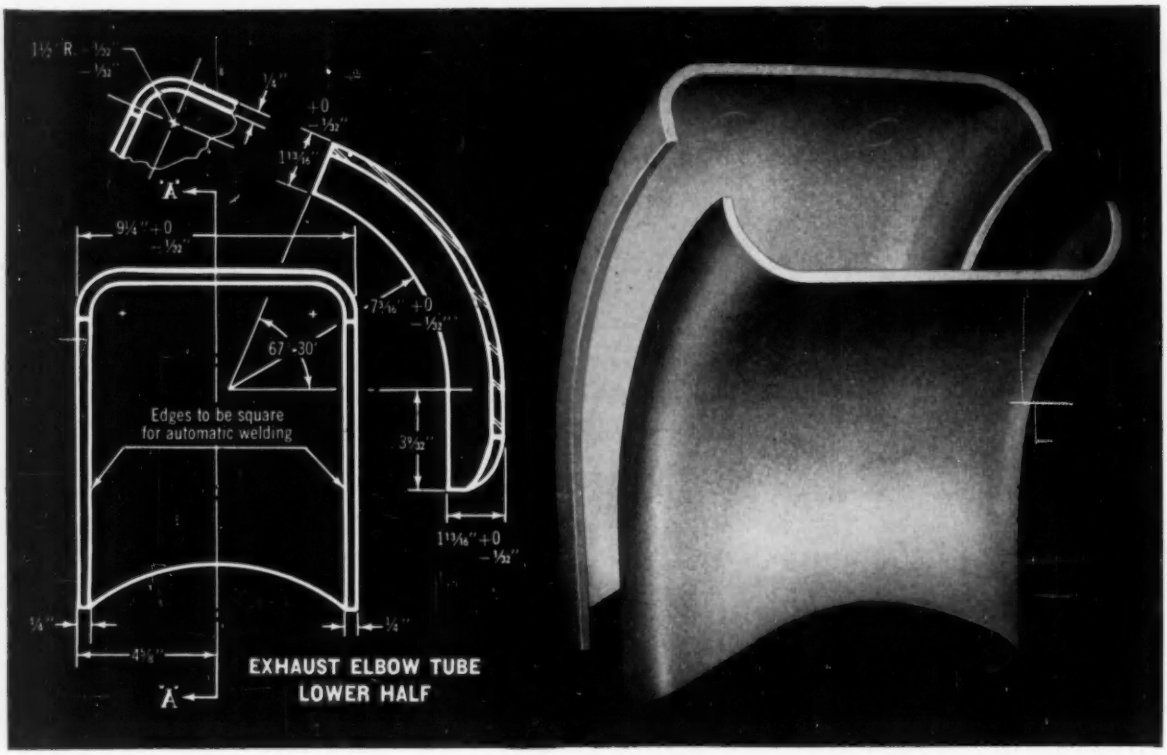


RUBBER PRODUCTS DIVISION, Section 526-CC
The Parker Appliance Company,
17325 Euclid Avenue, Cleveland 12, Ohio.
1538 South Eastern Ave., Los Angeles, Cal.

Please send:

☐ O-ring Size Catalog No. 5701
☐ O-Lube Catalog No. 5840

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____



Stamping tolerances held +0 -1/32" solve tough design problem

Previous attempts to fabricate diesel locomotive exhaust elbows by stamping had proved unsatisfactory. Tolerances necessary for production welding of the parts could not be held. Too many bad welds resulted and rejects piled up. Forging the part from hot rolled seamless tubing likewise proved too expensive.

Commercial engineers proved the elbows could be turned out as stampings and now Commercial is producing them from 1/4-inch flat steel with accurate tolerances of +0 −1/32.

These close tolerances are important because the two halves of the elbow are welded together automatically. If the opening between the parts is too wide, the weld metal will not bridge the opening. If it is too narrow, the metal will not penetrate the joint properly.

The accuracy of the Commercial dies also assures exact fit of both the square end of the tube, which is welded to the engine block opening, and the curved end, which is welded to a cylindrical manifold. No trimming of these ends is necessary.

The end result is consistently strong even welds at all points, few rejects, faster assembly. By switching from hot rolled tubing at 15 cents a pound to mild flat steel at 6 cents a pound, a substantial cost saving was also effected.

Custom stamping to very close tolerances of even very large or complex parts has long been standard operating procedure at Commercial.

We invite you to submit your blueprint, sketch, or sample for study. Commercial engineers can advise you without obligation on ways and means to improve the component parts. Very often slight design modification makes possible the use of Commercial's "die-bank" of over 2300 basic die components, resulting in substantial savings in the overall cost of the part.

Address inquiries or requests for forming engineering assistance to The Commercial Shearing and Stamping Company, Dept. G-44, Youngstown 1, Ohio.

SPECIALISTS IN CUSTOM FORMING THROUGH STAMPING • UPSET FORGING • HYDROSPINNING

COMMERCIAL
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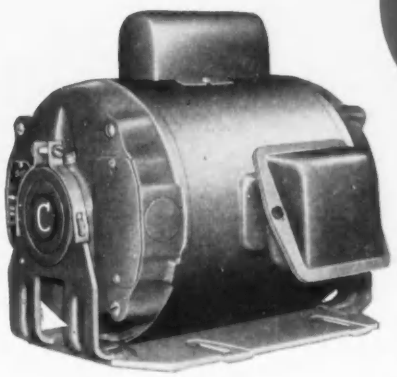
Your choice of normal or low starting current...

with Performance-Rated

Century

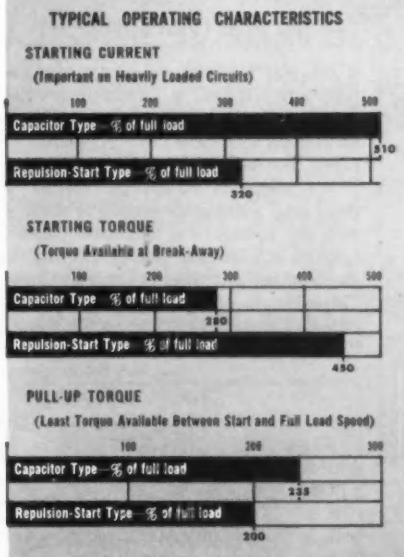
HIGH TORQUE, SINGLE-PHASE MOTORS

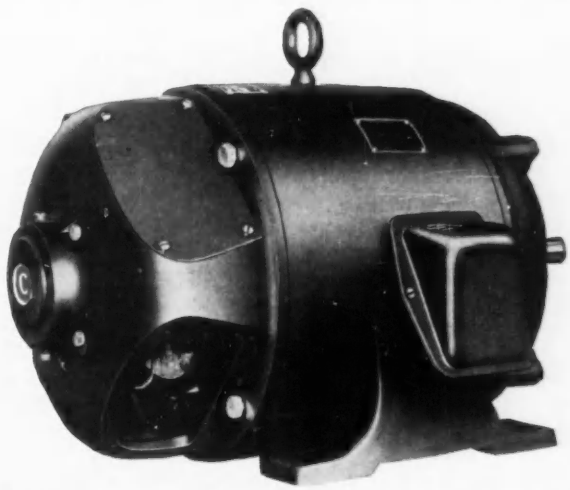


Capacitor Motors... ⅛ to 20 H.P. provide high starting torque, high pull-up torque and require normal starting current. They are available in drip proof, dust proof and explosion proof enclosures.

Even if you have severe starting current limitations, you can select the torque you need for sure starts and smooth pull-up to speed from the Century Performance-Rated Single-Phase line (see bar chart below for operating characteristics of two types of Century Single-Phase Motors).

Whatever Your Motor Job . . . there's a Century Motor Performance-Rated to handle it with top effectiveness. Contact your nearby Century branch office or Authorized Distributor.





Repulsion Start, Induction Motors (type RS)... ½ to 7½ H.P. provide very high starting torque, yet require unusually low starting current. They are available in drip proof and splash proof enclosures.

Performance-Rated©
Motors
⅛ to 400 H.P.

CENTURY ELECTRIC COMPANY

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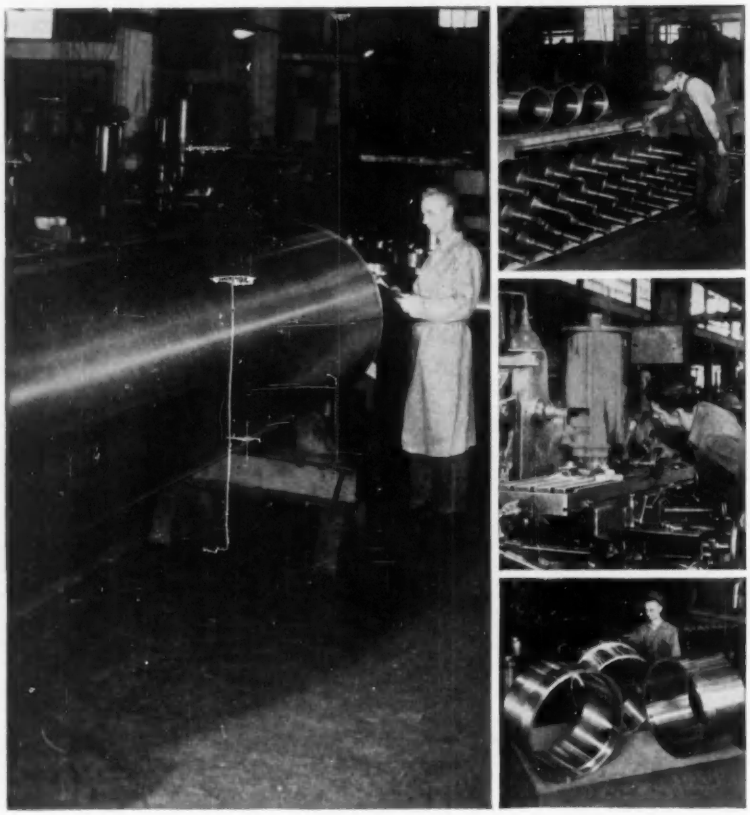

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WHATEVER the inside or outside pressures, Shenango centrifugal castings are better able to withstand them without failure.

Parts cast by the Shenango centrifugal process are much tougher because their finer, *pressure-dense* grain avoids stress concentrations while providing greater strength, better elongation and freedom from such costly defects as sand inclusions, blowholes and such.

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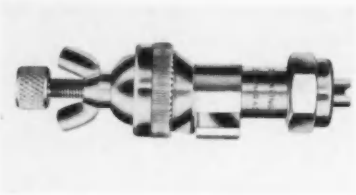

aphragm valve, shutoff screw and wingnut. Made of brass with internal Monel strainers. Available with a wide choice of interchangeable orifice tips covering a considerable capacity range, as well as selection of full cone, hollow cone and flat spray patterns. **Spraying Systems Co., 3201 Randolph St., Bellwood, Ill.**

For more information—
Circle 26, inside back cover

Two-pin Pilot Light Indicator . . .

is designed for mass production applications with GE No. 10, 12 and 15 two-pin indicator lamps. Made of high-impact melamine, with terminals of cadmium-plated beryllium copper. Available with a steel clip that clamps the holder on three sides and may be riveted or screwed to a flat surface or a lower-cost push-on fastener of cadmium plated steel that is mounted without rivets or other materials. Offered with or without bulbs or clips. **Eldema Corp., 9844 Remer St., El Monte, Calif.**

For more information—
Circle 27, inside back cover

Motors Built to New NEMA Ratings . . .

include protection against environmental hazards, two-way ventilation system for uniform cooling of the motor, a device for effective direction of air and deflection of water, improved asbestos insulation, and a solid-cast rotor. External parts are cast iron, including a split-type outlet box. Ball bearings are lubricated by a system in which grease is injected transversely

(Continued on page 126)

NEWS FROM FLEXONICS

HOSE APPLICATION ENGINEERING

One of a series of reports on more effective use of flexible hose.

HOW TO SELECT FLEXIBLE METAL HOSE

Selection of a suitable metal hose for most industrial applications can be reduced to four simple steps: (1) thorough investigation of the application, (2) choice of an appropriate metal, (3) determination of the most suitable hose type, and (4) selection of the proper end fittings and method of attachment.

Nature of the Application

The word "STAMP" is useful as a check list of major application requirements:

S – Size hose?
T – Temperatures?
A – Application's nature including motions?
M – Media to be handled?
P – Pressures?

Size and temperature considerations are normally routine although it is sometimes imperative to consider maximum, minimum, average, working and test values insofar as temperature is concerned. Motions, however, frequently determine the type of hose to be used.

Bend limitations of corrugated hose are subject to the elastic limits of the metal. Bending an interlocked hose depends upon the motion obtained from sliding in the interlocked joint. Therefore, when motions are machine controlled or hose is to be permanently bent, specify a corrugated (Flexon Rex-Weld or Rex-Flex) hose. Also, choose a corrugated hose for positive protection against leakage from searching gases and liquids.

Interlocked (Flexon Rex-Tube) hose is generally used for manual operation

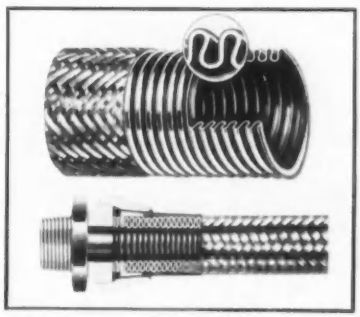

Fig. 1 — Typical Rex-Weld corrugated hose.

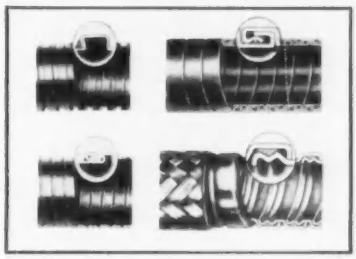

Fig. 2 — Examples of guard construction.

because the inherent design resists further bending when its minimum bend radius is reached. Using interlocked hose over a corrugated hose protects against abrasion or too sharp a bend to the corrugated hose.

Remember to specify corrugated (Flexon Rex-Weld) hose for: (1) searching or toxic fluids, (2) installations requiring sharp permanent bends, or (3) continuous vibration service.

Metal Selection

Metal selection is usually determined by the temperature and corrosive characteristics of the fluid being conveyed. Choice of a suitable packing for interlocked Rex-Tube hose is also a factor to consider.

Flexon hose specification tables give full data on maximum allowable temperatures. Past experience in handling a given medium is the best guide to selection of a metal with suitable corrosion resistance. However, bear in mind that corrosion rates acceptable for pipe could be ruinous to metal hose because of its relatively thinner wall. Consult Flexonics corrosion tables for detailed data.

Specific Hose Selection

The considerations outlined will have determined whether corrugated or interlocked hose should be used and the metal and packing required.

To determine which hose will be suitable concerning size, metal, pressure, weight, etc., consult Flexon industrial metal hose data tables in Flexon Metal Hose Design Guide. By using flexure data from these tables, the length of hose for any specific application can be determined.

Fitting Selection and Attachment

Fittings which are specially designed for soldering or mechanical attachment can be specified. Or pipe or tubing similar to adjacent piping can be selected for welding or brazing to the hose.

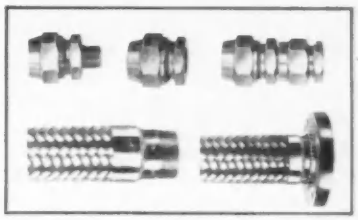

Fig. 3 — Typical metal hose end fittings.

Since the method of fitting attachment affects the maximum pressure and temperature rating of the assembly, it should be considered simultaneously with specific hose type selection.

Complete Selection Data Available

A new 36-page Flexon Metal Hose Design Guide expands the above data and presents the most complete information ever published on the selection and application of metal hose. It should be in every design engineer's reference file. Write for your copy, today.

G-38

HOSE DIVISION

Flexonics *Corporation*

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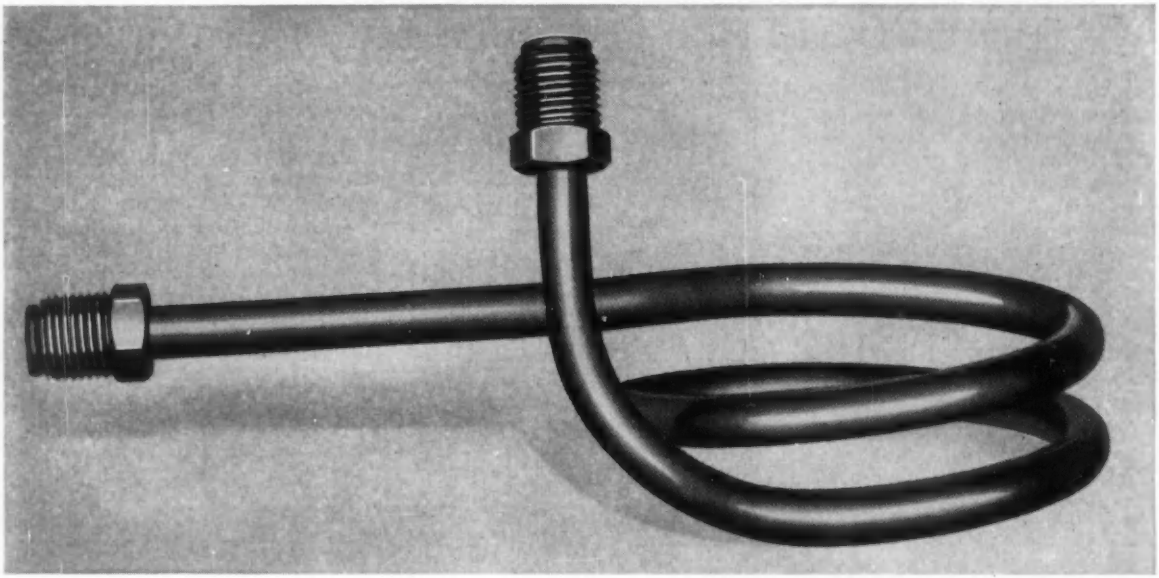
Space limits, low tolerances on brake tube call for Bundyweld's greater ductility



Double loop in this junction tube lets it meet rigid space requirements; also absorbs vibrations set up by differences in the movements of power cylinder and junction block. Tight tolerances are held on both the loop and the position of the ends, which are double-flared with fittings attached.

PROBLEM: Produce a junction tube to fit the restricted space between the power cylinder and junction block in a power-brake system . . . yet hold the low tolerances required for high-speed assembly.

SOLUTION: Take advantage of Bundyweld's greater ductility to design a *dual-purpose* junction tube — as Bundy® engineers helped one customer do. Not only does the tube meet limited-space and low-tolerance requirements . . . but its specially designed loop absorbs vibrations set up by differences in the movements of power cylinder and junction block.

Here again, Bundyweld® was chosen because its greater ductility permits holding tricky tolerances in mass production. And Bundyweld's high bursting strength assures long-lived *leakproof* performance in any high-pressure hydraulic system . . . one reason it has become the safety standard of the automotive industry. *95% of today's cars use Bundyweld, in an average of 20 applications each.*

Bundy's skilled fabricators mass-produce the junction tube—coil the tubing, attach the fittings and then double-flare the tubing ends. Finished parts are delivered on schedule . . . clean and ready to use.

If *you* want to save time, hold down costs on tubing design or fabrication, check first with Bundy. Call, write, or wire us today.

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WORLD'S LARGEST PRODUCER OF SMALL-DIAMETER TUBING. AFFILIATED PLANTS IN AUSTRALIA, ENGLAND, FRANCE, GERMANY, AND ITALY

Bundyweld starts as a single strip of copper-coated steel. Then it's
. . . continuously rolled twice around laterally into a tube of uniform thickness and passed
through a furnace. Copper coating fuses with steel. Result . . .
SIZES UP TO ⅝" O.D.
Bundyweld, double-walled and brazed through 360° of wall contact.

NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

THERE IS NO REAL SUBSTITUTE FOR

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DOUBLE-WALLED FROM A SINGLE STRIP

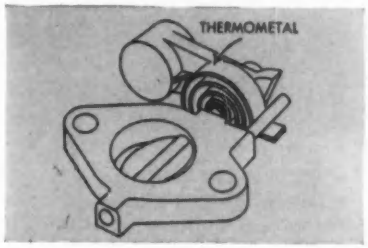
No. 4
of a series of ads dealing with basic facts about thermostatic metals.

Designing for Product Improvement With WILCO THERMOMETAL®

Thermometal in Temperature Compensation

Many devices and instruments are affected by ambient temperature changes which results in inaccuracy or inefficient operation. Since Thermometal can transform temperature changes into mechanical motion it can be used to compensate these products for practically any function which is sensitive to temperature change and improve their performance.

Typical examples are. In the modern automotive carburetor, a Thermometal helix automatically closes the choke valve with decrease in temperature thereby increasing the fuel-air ratio for a faster start on cold days. As the engine warms up the choke opens again reducing the fuel-air ratio. And a Thermometal coil also actuates the automatic manifold heat control which bypasses hot exhaust gas around the intake manifold until the engine is fully warmed, then directs it back into the muffler.

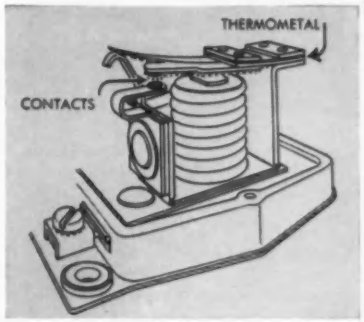


Even the voltage regulator air gap is varied by a Thermometal hinge or cantilever blade in order to obtain best ambient temperature performance.

Thermometal temperature compensating elements are also used in electrical appliances, aircraft instruments, timing relays, circuit breakers, and a great variety of electrical devices.

Thermometal is ideally suited for temperature compensation because:

1. It can be used to transform temperature change into motion or pressure

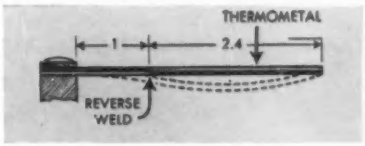


without complicated linkages or fluid systems, such as diaphragms or bellows.

2. The use of a Thermometal spiral or helix is the simplest and most economical method to transform temperature changes into a rotary motion without the use of gears or other complicated mechanical systems.

3. Thermometal is the most economical method for providing a small motion required to compensate for ambient temperature effects of other temperature-sensitive devices, such as bulb and bellows thermostats, thermocouple cold junctions, electrical appliances, etc.

4. By specific design and choice of one or more Thermometals, it is possible to obtain an inherently temperature-compensated element which will not respond to ambient temperature changes, but will respond to differential or non uniform heating.



Thermometal is a unique temperature-compensating element because it can be rolled into any thickness and formed into almost any shape as required. It is used in the form of cantilever blades, U-shapes, spirals and helices, in almost any mechanical size and configuration, as required to provide specific temperature compensation. It is the most economical method of obtaining ambient temperature compensation, and is singularly free from the limitations of other temperature compensators.

Factors Governing Selection

1. Temperature range over which compensation is required.

2. Maximum and minimum temperature encountered in service.

3. The amount of movement or force required to effect compensation.

4. Electrical and thermal conductivity required for the application.

5. Space limitations which govern shape required

The H. A. Wilson Company, American pioneer in the development and manufacture of thermostatic metals, produces over 40 varieties of Thermometal, as well as a complete line of electrical contacts. In many temperature control units both Thermometal and electrical contacts are used. We make a specialty of supplying complete sub-assemblies for these devices, including mounting brackets, pigtails, and other current-carrying members.

Reprints of this series are available on request. For further information about our products, ask for the Wilco Blue Book, the most complete reference manual ever written on Thermometal. And if you have any immediate application problem for Thermometal or other Wilco products, please tell us. Our engineering service is at your disposal.

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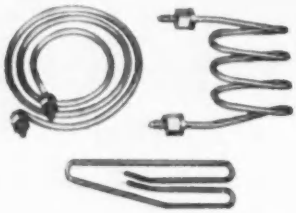
When to specify

VULCAN ELECTRIC TUBULAR HEATERS



1. When application is for: Considerable heat — confined space. Straight or formed in variety of shapes for liquid, gas or metal heating applications. For casting into iron or aluminum. With threaded fittings for liquid immersion heating (water, oil, etc.).

2. When specifications call for: Length — 10″ to 148″; diameter — .250″, .280″, .333″, .450″; wattage — 10 to 10,000 (or higher); voltage — standard 115 or 230, special 6 to 440; sheaths — copper, steel, high temperature alloys.

3. When you have "hot" problems: Vulcan Engineers are ready to provide special heating units — engineered to your needs.

***NEW* FINNED TUBULAR HEATERS**

Vulcan's new Finned Tubular Heaters provide six times as much radiating surface as standard tubular heaters. Fin is spirally edge wound from continuous strip of steel, then silver brazed to surface of sheath. Heaters can be formed at factory into one or a series of hairpin bends.

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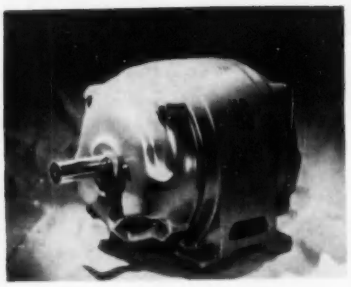


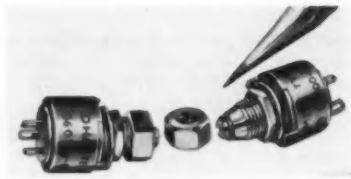
through the bearing, completely replacing old grease. **U.S. Electrical Motors, Inc., Box 2058 Terminal Annex, Los Angeles 54.**

For more information—
Circle 28, inside back cover

Centerless Ground Shafting . . .

is available from stock, ground to ±0.0001 in. dia and finished to a 10 micro finish or better. Delivery can be made immediately from stock on all sizes from $\frac{3}{32}$-in. to $\frac{1}{2}$-in. dia. Shafting is stainless steel. **PIC Design Corp., Sub. of Benrus Watch Co., Inc., 477 Atlantic Ave., East Rockaway, N. Y.**

For more information—
Circle 29, inside back cover



Tiny Potentiometer . . .

$\frac{1}{2}$-in. dia and rated at 0.5w continuous duty. Furnished in linear taper with locking, screwdriver-slotted shafts. Units are dust-tight, splash-proof and fungus-resistant. Terminals are gold-plated. Available in 15 resistance values from 100 ohm to 5.0 megohm. **Ohmite Mfg. Co., 3630 Howard St., Skokie, Ill.**

For more information—
Circle 30, inside back cover

Spring Return Cylinders . . .

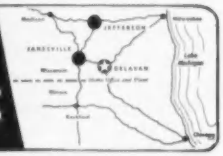
for holding, ejecting, work-feeding and assembly fixtures are available with adjustable-length, hardened pad on ram end that will swivel 15° in any direction so that it can hold uneven work pieces. Threaded screw with locknut allows $\frac{1}{2}$-in. length adjustment. Has 1-in. bore and 1-in. stroke. Square ends permit horizontal or vertical mounting. Also available with

(Continued on page 128)

WHO IS BORG?

Borg is a highly respected name in its field . . . the manufacture of components for systems. Borg has gained wide recognition as a supplier of electronic components for military and commercial uses.

BORG PLANTS



Borg manufacturing plants are centrally located about 90 miles from Chicago. Easily accessible by highway, rail and air.

WHAT BORG MAKES

Precision Is Our Business. For many years Borg has been prominent in the design and manufacture of precision components for systems.

- **AIRCRAFT INSTRUMENTS** Aircraft components, instruments and electronic sub-assemblies.
- **FREQUENCY STANDARDS** Crystal controlled oscillator type frequency standards.
- **POTENTIOMETERS** Quantity production of Borg MICROPOTS (precision potentiometers) to meet your specifications.
- **MICRODIALS** Precision MICRODIALS for single and multi-turn devices. Indexed accuracy of up to one part in 1,000.
- **INSTRUMENT MOTORS** Precision motors, synchronous and induction types. Gear trains.

BORG CAN HELP YOU

Borg can assist you in the design and construction of prototypes. Complete facilities for pilot runs and quantity production. Write for Bulletin BED-A50 or call us today.

BORG *Built by Borg*
MOTORS
MICROPOTS
MICRODIALS

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

Shock after Shock

THROUGH THE SONIC BARRIER...

BORG MICROPOTS Can take it!

NEW!

BORG 910 SINGLE-TURN PRECISION MICROPOT

The new Borg 910 Series Single Turn Micropot retains its high precision characteristics through severe vibration and shock. Borg 910 Micropots were developed from the Borg 900 Series Micropots . . . long preferred in aircraft and electronic fields for accurate, long lived dependability. Let your nearest Borg "Tech-Rep" show you the many advantages offered by the new Borg 910 Series Single Turn Micropot.

WRITE FOR CATALOG SHEET BED A-69 AND NAME OF YOUR NEAREST BORG TECH-REP

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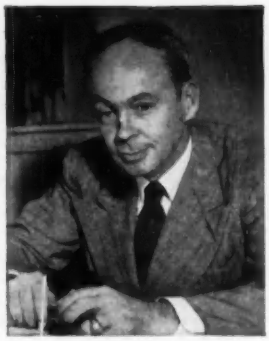
ELECTRONIC – MECHANICAL BORG EQUIPMENT

Built by Borg

MOTORS
MICROPOTS
MICRODIALS

MICRO-BEARING ABSTRACTS

by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.



DYNAMIC AND STATIC LOAD RATINGS

Load ratings of MICRO bearings are based on standards established by the Anti-Friction Bearing Manufacturers Association and are the result of extensive tests.

The "life" of an individual bearing is defined as the number of revolutions the bearing makes before the first evidence of fatigue develops. Fatigue, in turn, is a function of bearing load and although other factors, such as contamination and high temperature, affect the life of a bearing, it is assumed that clean bearings running at normal temperatures are being considered.

It is not possible to predict the life of any individual bearing. The problem, therefore, is best approached by a consideration of empirically derived dispersion curves which provide a means of determining bearing life on a probability basis. That is, they permit the average life of a given group of bearings to be accurately specified.

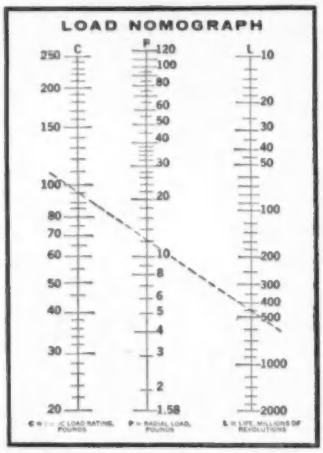
For purposes of standardization, the "rating life" of a group of apparently identical ball bearings is defined as the number of revolutions that 90% of the group will complete or exceed before the first evidence of fatigue develops. This figure is approximately one-fifth of the average life.

If two groups of similar bearings are run under different loads F_1 and F_2 within normal operating range of loading and rpm, their lives L_1 and L_2 are inversely proportional to the cubes of the loads, i.e., The BASIC LOAD RATING C is that radial load which a group of apparently identical bearings can endure for a rating life of one million revolutions, with stationary load and rotating inner ring. Within normal operating ranges, rating life for any load is a constant number of revolutions, so the following relationship, a restatement of the inverse cube proportion, may be used to compute rating life when basic load rating and applied radial load are known:

$$L = \left(\frac{C}{P}\right)^3$$

L=rating life in millions of revolutions
where, C=basic load rating in pounds
P=applied radial load in pounds

The nomograph illustrated permits the quick evaluation of any one of the three quantities when the other two are known. For example, if the C rating of a given bearing is 95 pounds, and the bearing is loaded radially with



12 pounds, P, a straight edge crossing these two values in their respective columns shows that the bearing could be expected to have a life, L, of 450 million revolutions.

"EQUIVALENT LOAD"

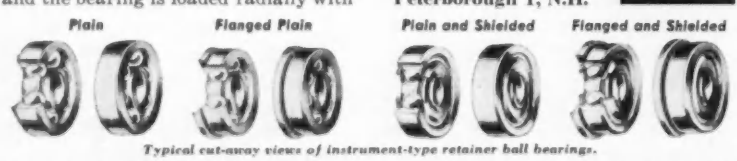
Bearings whose loads are primarily radial are usually also subjected to axial forces. When the axial component of the load is greater than a negligible value, this combined radial and thrust load may be expressed in terms of a simple radial load in order that the basic load rating C may be calculated. This simple radial load is known as the "equivalent load", which is that constant stationary radial load which, if applied to a rotating inner ring, would give the same life as that which the bearing will attain under the actual conditions of load and rotation.

A formula for determining "equivalent load" and a more comprehensive discussion of static and dynamic loads is found in our design handbook.

DESIGN HANDBOOK OFFERED *FREE*

You'll find this new, 70-page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.

Write to: New Hampshire Ball Bearings, Inc., Peterborough 1, N.H.

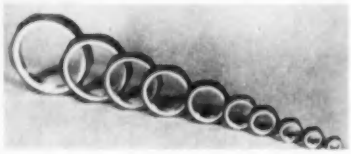


Typical cut-away views of instrument-type retainer ball bearings.

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE

½-in.-dia ram that has ⅜-18 tapped hole in ram end. **Wm. McLaughlin & Assoc., 23 W. 155 St., Gardena, Calif.**

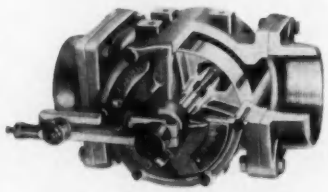
For more information—
Circle 31, inside back cover



Corrosion-resistant Pipe Fitting . . .

has been given a new surface treatment that withstands the 100-hr salt spray test. Finish is gold-colored. Edges of the fitting, designed to stop leaks at threaded pipe connections, have been cropped and rounded to make the device compact. Fitting is sealed by a threaded Teflon insert. **Flick-Ready Corp., 2040 N. Hawthorne Ave., Melrose Park, Ill.**

For more information—
Circle 32, inside back cover



Adjustable Port Valve . . .

permits accurate control with low operating torque of air or gas flow at pressures to 24 psig and temperatures to 400 F. Holds desired settings in automatic or manual control systems and provides flow rate over the full control range by 90°-rotation of its lever. The lever rotates a cylindrical piston for the desired port opening. Adjustable radius and positioning permit linkage to a control motor or drive mechanism. **Hauck Mfg. Co., 124-36 Tenth St., Brooklyn 15, N. Y.**

For more information—
Circle 33, inside back cover

Subminiature Timer . . .

weighs 6 oz, is 1¼ in. square and is custom-built for applications where weight and space are vital. Hermetically sealed, the timer is designed for 115 v, 400 cps; 115 v, 60 cps, and 28 v dc. Mounting mechanism is internally shock-mounted to meet applicable military specifications.

(Continued on page 130)

You Cut Costs with Aeroquip 2802 Hose (Teflon*) Because "*super gem*" Fittings are Reusable!

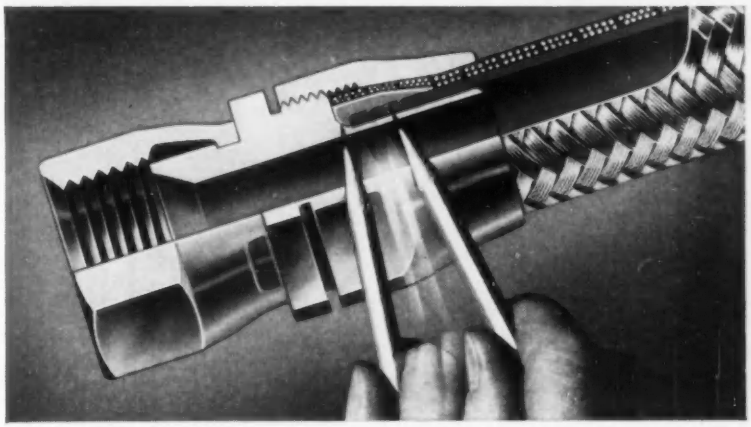
PROLONG LIFE OF FLUID SYSTEMS SUBJECT TO HIGH TEMPERATURES, CORROSIVE CHEMICALS

Hose lines of Teflon give unequalled performance wherever extreme fluid temperatures are encountered, or where chemical stability, lubricity, flexing and long service of the hose are critical factors.

In selecting a hose line of Teflon, important advantages can be gained by giving consideration to the type of fitting used with the hose. For best results, it must be designed to (1) give leakproof performance in prolonged operation and (2) permit disassembly and reuse of the entire fitting.

Only the Aeroquip "super gem" Fitting meets both of these requirements.

The need for a permanently leakproof fitting is obvious in conveying such fluids as live steam and strong acids and bases. How the "*super gem*" Fitting is designed to give double protection against leakage is shown in the illustration at the right.



Cutaway of a "*super gem*" Fitting, with line seal pointed out at left and lip seal at right. Together they furnish permanent protection against leakage. Note how fitting grips only the wire cover, preventing cold flow of the inner tube of Teflon.

REUSABLE FITTINGS CUT COSTS

Due to the relatively higher cost of hose lines of Teflon, the fitting that can be completely salvaged and reused offers substantial savings in cost. The Aeroquip "*super gem*" Fitting can be assembled and disassembled on hose line of Teflon quickly using ordinary bench tools. No expensive swaging machines are required. This permits quick engineering mock-ups and modifications.

In the typical hose assembly of Teflon shown at the left, the fittings account for 54% of the total cost. On the production line or in final use, the entire hose line of Teflon need not be scrapped if an alteration is made involving these fluid lines. In all cases, Aeroquip "*super gem*" Fittings can be disassembled and salvaged completely.

WIDE RANGE OF FITTING SIZES AND MATERIALS

Aeroquip 2802 Hose of Teflon is available in sizes from ¼" to 1". "*super gem*" Fittings are available in aluminum alloy, stainless or carbon steel. Male pipe fittings are available in carbon steel only.

Full information on Aeroquip 2802 Hose of Teflon and reusable "*super gem*" Fittings is available. Fill in and mail the coupon below for engineering bulletin IEB-26A.

Complete engineering assistance is available to manufacturers.

SEE OUR CATALOG PAGES IN SWEET'S PRODUCTS DESIGN FILE, SECTION 6D.

SPECIFICATIONS—AEROQUIP 2802 HOSE

DASH SIZE	−4	−5	−6	−8	−10	−12	−16
O.D. Tube Size	¼	5/16	⅜	½	⅝	¾	1
Hose I.D.	3/16	¼	5/16	13/32	½	⅝	⅞
Hose O.D.	5/16	⅜	7/16	17/32	21/32	25/32	1 1/32
Max. working psi.	2000	2000	1750	1500	1500	1250	1000
Min. burst psi.	12000	10000	9000	8000	7000	6000	4000
Min. bend radii. (ins.)	2	3	4	4⅝	5½	6½	8
Wt./ft. (lbs.)	.084	.093	.118	.146	.205	.240	.338

All dimensions in inches.

*DuPont trade name for its tetrafluoroethylene resin.
"*super gem*" is an Aeroquip Trademark.

Aeroquip Corporation
Jackson, Michigan

Please send me the following information on reusable "*super gem*" Fittings and Teflon Hose:

☐ Industrial Engineering Bulletin IEB-26A.
☐ Aircraft Engineering Bulletin AEB-13.

PE-10

Name_____
Title_____
Company_____
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AEROQUIP CORPORATION, JACKSON, MICHIGAN

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MARMAN DIVISION, LOS ANGELES, CALIF.; GENERAL LOGISTICS, PASADENA, CALIF.; AEROQUIP (CANADA) LTD., TORONTO 10, ONTARIO.

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Immediate Delivery

ANY BORE SIZE • ANY MOUNT • ANY STROKE

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Sounds too good to be true, but here's real help for engineers and designers who need fast action on cylinders. Carter's exclusive key type locking design and simplicity of parts *makes it possible to ship cylinder orders in 24 hours or less!* Now you can have rugged, dependable, compact quality cylinders when you want them. We produce around the clock. Your order is in process *minutes after we get it.*

Service on spare parts is good too! Experienced engineers and parts stocks are located in 40 different locations in the U. S., Canada and Mexico.

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Complete Catalog File!

Complete bound file with ordering details for: Air Cylinders; 750 Lb. Hydraulic; 1500 Lb. Hydraulic; Clamp Cylinders; Air Valves; Built-in Valve Type Cylinders. Complete with parts data, specifications and prices. Send today!

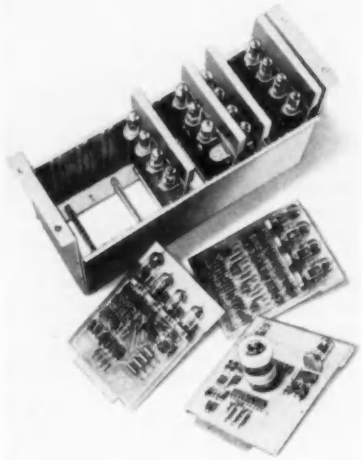
CARTER CONTROLS INCORPORATED

2884 Bernice Road • Lansing, Illinois (Chicago Suburb)

AIR CYLINDERS • HYDRAULIC CYLINDERS • AIR VALVES
ROTARY ACTUATORS • SPECIAL CONTROLS

Operates in temperatures of —55 to 125 C and to altitudes of 60,000 ft. **Advanced Products Co., 59 Broadway, North Haven, Conn.**

For more information—
Circle 34, inside back cover



Plug-in Etched-circuit Component Cards . . .

allow more flexible breadboard design, faster development time, and reduction in over-all data processing and computer system costs. Component card group comprises quadruple clamped flip-flops, quadruple clamped inverters, decimal counters, read-write amplifiers, cathode followers and blocking oscillator cards. Also included are diode logic cards, constructed to particular requirements, and general-purpose blank panels. Cards are 6 in. wide x 8 in. deep. Using the special mounting bracket, up to nine cards can be mounted in a standard 19-in. rack. Gold-plated, etched copper conductors on $\frac{1}{16}$-in. epoxy-glass are employed. Two-sided plug contacts are nickel and rhodium-plated. **BJ Electronics, Borg-Warner Corp., 3300 Newport Blvd., Santa Ana, Calif.**

For more information—
Circle 35, inside back cover

High-torque, Low-watt Synchronous Motor . . .

is designed for 12,000 rpm on 400 cps, and has 0.85 oz-in. pull-out torque with 20-w power consumption. The size-18, single-phase, two-capacitor 400-cps motor can also be hooked up as a two-phase motor at 0.93 oz-in. pull-out torque with 14.7 w; or as capacitor-resistor motor at 0.73 oz-in. pull-out torque with 30 w.

(Continued on page 133)

We can help

you "fit"

WIRE CLOTH

to your needs

These days, "fit" is an appropriate word when it comes to matching wire cloth to industrial needs—especially when you do business with the *Reynolds Wire Division* of National-Standard. Here's why . . .

First, there are of course the many different weaves, meshes, metals, finishes and coatings that provide for infinite combinations to meet any special requirement right on the nose.

Secondly, and highly important, Reynolds also "tailors" wire cloth to the precise *width* and *length* needed to minimize waste and to shave the last bit of excess cost out of production operations.

Finally, Reynolds helps you take the fullest advantage of these variables by providing truly unmatched engineering and analytical service . . . nation-wide. Can wire cloth do a *better* job for you? Can you cut costs? Could wire cloth be the answer for certain *new* requirements? Check with Reynolds . . . see what *Reynolds* service and quality control offers!

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WAGNER LITHO MACHINERY, Secaucus, N. J.; *metal decorating equipment* • ATHENIA STEEL, Clifton, N. J.; *flat, high carbon spring steels* • REYNOLDS WIRE, Dixon, Ill.; *industrial wire cloth*

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...and there's a copy waiting for you!

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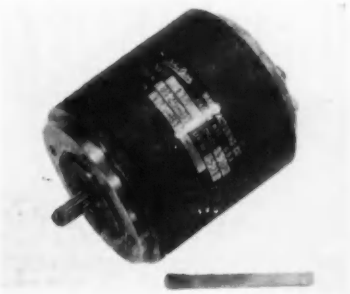
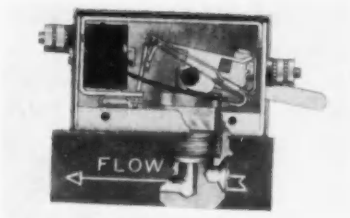
Aetna AETNA BALL AND ROLLER BEARING COMPANY
DIVISION OF PARKERSBURG-AETNA CORPORATION • 4600 SCHUBERT AVE., CHICAGO 39, ILL.



Motor meets applicable military specifications, weighs 14 oz and is furnished with pinion type shaft, terminal block construction and stainless steel housing finished in black oxide. **John Oster Mfg. Co., Avionic Div., Racine, Wis.**

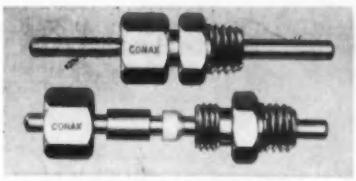
For more information—
Circle 36, inside back cover



Magnetic Shut-off Valve . . .

has built-in circuit breaker for diesel engines to eliminate battery drain after shutdown. Batteries rated 4 to 32 v can be used to close the valve—a regular engine-starting battery or 6-v hotshot will do. Valve has manual latch for opening. Connects to any of the firm's temperature or pressure gage-switches. With ¼-in. port, ⅜-in. IPT connections, a machined-brass body, and over-all dimensions of 3 x 2¾ x 2 in. Semi-automatic operation. **Frank W. Murphy Manufacturer, Inc., P.O. Box 1476, Tulsa, Okla.**

For more information—
Circle 37, inside back cover



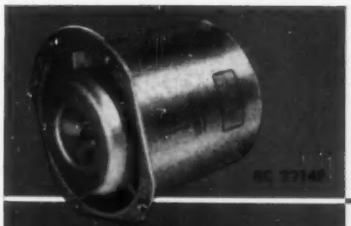
Small Packing Glands . . .

with Teflon sealant have temperature range from —90 F to 500 F and seal pressures from 0.005 microns to 1000 psi. With lava sealant, temperatures range from —300 F to 1850 F with pressures

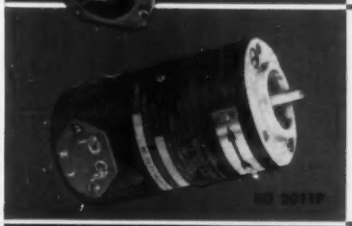
(Continued on page 134)

IMC MOTORS

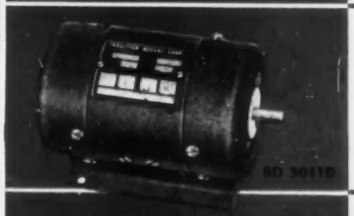
precision with a purpose



2900 Frame Motor
INPUT: 400 cycles, 1 phase capacitor type 225 watts (motor can be wound 3 phase AC or DC)
OUTPUT: 200 cfm @ 2.50″ H_2O sp at standard conditions and 8000 rpm
WEIGHT: 5½ lbs
Bulletin 29F1



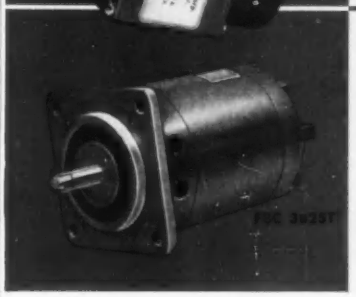
2000 Frame DC Motor
INPUT: 6-115 volts DC
OUTPUT POWER: 1/75 to 1/10 hp depending on speed, duty cycle and cooling
LIFE: 1000 hr brush life; 250 hrs at high altitude
Available with gear speed reducer and/or speed governor, shunt, series, or compound wound.
Bulletin 20F2



3000 Frame Dynamotor
INPUT: 6-115 volts as specified
OUTPUT VOLTAGE: 6-450 volts as specified
OUTPUT POWER: Up to 100 watts, depending on duty cycle and cooling
WEIGHT: 5⅛ lbs
Bulletin 30F3

900 Frame AC Motor
FREQUENCY: 320-1000 cps
AIR DELIVERY: 10 cfm @ 0″ sp; 8 cfm @ 0.2″ sp
RPM: 7000 @ 400 cps
WEIGHT OZ.: 7
WEIGHT OF MOTOR OZ.: 4½
*Also available in 1″ blower size.
Bulletin 9F4

1500 Frame Dynamotor
SIZE: 1½ x 1½ x 3 in.
WEIGHT: 1 lb
LIFE: 100 hrs brush life at 50,000 ft altitude, 500 hrs at sea level
Bulletin 15F5



3800 Frame AC Motor
INPUT: 26-230 volts AC; 1, 2 and 3 phase
INPUT FREQUENCY: 25-400 cycles
NUMBER OF POLES: 2, 4, 6, 8 and 12 poles
OUTPUT POWER: Induction motors—to 1 hp
Torque motors—10 to 200 oz. in. stall torque
Hysteresis synchronous motors—1/200 to ¼ hp
(Can be wound for single, dual or three speed.)
BEARINGS: Ball or sleeve
WEIGHT: 8-11 lbs
Bulletin 38F6

These units, as are others in the complete IMC line of dynamotors, servo, gear, blower and actuator motors, are constructed to meet MIL specifications for environment and performance. For further information, write

Induction Motors Corp.
570 Main St., Westbury, L. I., N. Y. Phone: EDgewood 4-7070

HOLTZER -CABOT

Synchronous and Induction Capacitor Type Motor

Approximately 2½" in diameter, the R-25 is available in either induction or synchronous construction with reversible rotation.

Typical applications are in recording instruments, dictating and adding machines. Available with gear case speeds from ½ to 3600 RPM, torque ratings up to 75 oz. inches or higher, and single, 2 or 3 phase.

HOLTZER-CABOT MOTOR DIVISION
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston 19, Mass.

GENTLEMEN: ☐ Please send me data sheets on the Holtzer-Cabot R-25 Motor.

☐ Please have representative call on ..... (date)

Name.....

Company.....

Street.....

City.....Zone....State.....

New Parts and Materials.....continued

from 0.005 microns to 3000 psi. Measure $\frac{3}{8}$ x $\frac{1}{2}$ in. long x $\frac{1}{2}$ in. hex. Can be used to seal tubes of any material. Reduction in stress concentration increases fatigue strength. Standard bore sizes are $\frac{1}{8}$ in. and $\frac{3}{32}$ in. with $\frac{1}{16}$ in. IPS thread. Nonstandard bore sizes range from 0.030 in. to 0.096 in. **Conax Corp., 2300 Walden Ave., Buffalo 25.**

For more information—
Circle 38, inside back cover

Hand Cranks, and Nameplates . . .

to fit each hand crank, are offered from stock in bore sizes of $\frac{1}{8}$, $\frac{5}{16}$ and $\frac{1}{4}$ in. Cranks are cast aluminum anodized in chromic acid. **PIC Design Corp., Sub. Benrus Watch Co., Inc., 477 Atlantic Ave., E. Rockaway, N. Y.**

For more information—
Circle 39, inside back cover

O-ring Compound . . .

has been UL-approved for service in propane, butane, home fuel gases, gasolines of all types, including auto engine fuels, and fuel oils including the No. 6 grade. **Precision Rubber Products Corp., Dayton, Ohio.**

For more information—
Circle 40, inside back cover

Standard-duty Pushbuttons . . .

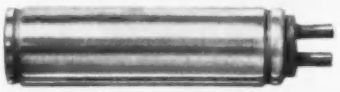
have a base-mounted control mechanism and front-accessible wiring terminals. Reversible formed steel base includes knockout and a pipe connection that provides wiring from either end or straight through. Can be furnished with one normally-open contact, one normally-closed contact, or one normally-open and one normally-closed contact on each button. Two- or three-button units are standard. Wraparound cover is molded of glass-fiber-reinforced alkyd. Buttons provide economical

(Continued on page 136)

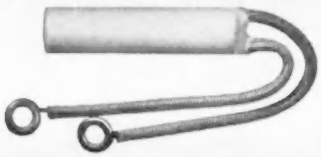
Need a little heat?

NEED IT HOT?

SPECIFY



HOTWATT®



HEATING CARTRIDGES

HOTWATT

Precision Heating Cartridges provide optimum ambient and operating temperatures . . . supply faster heating . . . have higher heat density . . . minimize heat loss.

STANDARD HOTWATT

Cartridge Heaters have precision-dimension stainless steel sheaths (special alloys available) . . . operate at up to 1250°F, any specified voltage . . . nickel alloy leads swaged to rigid external terminals . . . straight or right angle leads . . . moisture resistant units . . . complete range of sizes from $\frac{3}{16}$" dia. x 1" length.

SPECIAL HOTWATT

Heating Cartridges in special shapes with sheath materials as designated available with power dissipation as low as 5 watts. Special terminal or lead arrangement to specification.

LOW-COST HOTWATT

ceramic-body units are also available, to your design and specifications; sizes as small as $\frac{5}{32}$" . . . lead arrangements and terminals to meet your requirements.

SPEEDY DELIVERY

HOTWATT'S versatile production line easily handles long or short runs of cartridges to your "specs" . . . provides the fastest delivery in the industry.

Bulletin 101 and Cartridge Layout Sheet available on request.

HOTWATT, INC.
ELECTRIC HEATING SPECIALISTS
16 Gould St., Danvers, Mass.

"U" packings & cups
VIM wax or rubber impregnated leather "U" Packings . . . or VIX-SYN homogeneous synthetic rubber "U" Cups
cups
VIM wax or exclusive rubber impregnated leather
"O" rings
VIX-SYN synthetic rubber
"V" packings
VIM wax or rubber impregnated leather . . . or VIX-SYN homogeneous and fabricated synthetic rubber

The Pick of the Packings in EVERY Material

When recommending packings, the Houghton man asks himself only one question . . . "What's the best packing for the job?" For his company has them all. In wax or rubber impregnated leather . . . in homogeneous synthetic rubber . . . in fabricated synthetic rubber. He has no pets to push, no pressure to promote any one material. His lone loyalty is to you, the customer. Drawing on his broad engineering experience, plus the research findings of Houghton, he can impartially recommend the packings that will best answer the specific problem . . . regardless of the raw materials that go into them.

And when purchasing Houghton packings, you can be sure you're utilizing the latest design and material developments. For Houghton research is continually finding new and better ways to improve their packings. Two recent Houghton developments illustrate this . . . spring mounted cup packings and standard stack heights for "V" packings. The first lets cup packings wear longer by giving them "breathing action" in the cylinder . . . the second means that now all "V" packings, regardless of materials, fit the same gland. When you have packing problems, call your Houghton man. Or write E. F. Houghton & Company, 303 West Lehigh Avenue, Philadelphia 33, Pennsylvania.

. . . products of

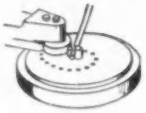
E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

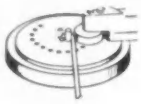
Ready to give you on-the-job service . . .

HOW TO BEND
BARS and TUBING

HOW TO BEND . . .
OFF CENTER EYES



1. Insert bar stock between Locking Pin and Radius Pin of desired size.



2. Set Forming Roller against material and advance Operating Arm.

3. Complete operation with one steady movement.

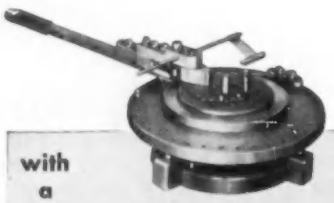
HOW TO BEND . . .

TUBING

1. Clamp tube. Insert Follow Block between material and Forming Roller.

2. Advance Operating Arm until it strikes Angle Stop.

3. Remove Follow Block, release clamp and remove tube.



with a

DI-ACRO BENDER

Complete details on forming rods and tubing with standard accessories as well as tips and technical data on angle, channel and other materials will be found in "It's Easy to Bend", a 32 page summary of Di-Acro Benders and bending. A copy is yours free of charge.

Consult the yellow pages of your phone book for the name of your nearest Di-Acro distributor or write:

pronounced die-ack-ro

O'NEIL-IRWIN MFG. CO.
333 8th Ave., Lake City, Minn.

di-acro PRECISION METALWORKING MACHINES

pilot control for magnetic controls and solenoids of other magnetically operated devices. Ac contact ratings are 3 amp, 110 v; 1.5 amp, 220 v; 0.75 amp, 440 to 480 v; and 0.6 amp, 550 to 600 v. The dc contact ratings are 1.1 amp, 115 v; 0.55 amp, 230 v; and 0.2 amp, 550 to 600 v. **Furnas Electric Co., 1050 McKee St., Batavia, Ill.**

For more information—
Circle 41, inside back cover

Digital Voltmeters . . .

with 4 or 5 digits measure with 0.01% accuracy, with measurement displayed by 1-in.-high, edge-lighted numerals. Contacts are also provided for control circuits. Units combine dc switch modules with universal power modules for an input signal range of 0.1-milliv to 1000-v. Input filter is rated 40 db at 60 cps. Modules are 19 x 12 in. **Electro Instruments, Inc., 3794 Rosecrans Ave., San Diego, Calif.**

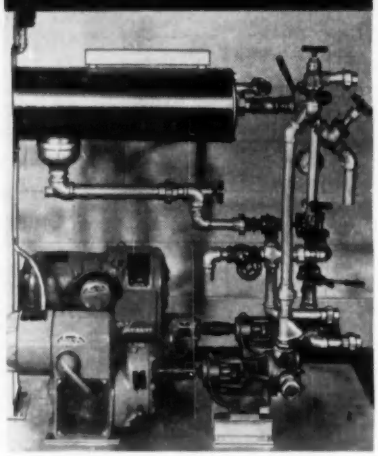
For more information—
Circle 42, inside back cover

Plastic Variable Speed Pulley . . .

has been designed for fhp, ¼-in. V-belt drive. Molded of nylon reinforced with glass fiber, the pulley is self-lubricating, has good chemical resistance, and long-

(Continued on page 138)

Would
PRECISION PUMPING
help you too?



Thermal unit does successful job with Viking Pumps

Precision pumping by two Viking heavy-duty pumps contributes much to the highly successful operation of starch cooking units built by Thermal Equipment Corporation, Skokie, Illinois.

WHERE USED—Units cook starch continuously in many applications, including paper, textile, food and other fields. Example: unit easily cooks 25% paste of unmodified cornstarch.

HOW USED—With variable speed drives, the pumps are used to regulate the mixture of slurry and water in the pressure chamber. The slurry pump can be varied from 0.5 to 5.0 gallons per minute—the water pump from 5.0 to 20.0 gpm.

WHAT VIKINGS CAN DO FOR YOU

Whether you need precision pumping or have some other pumping problem, Vikings may be your answer. Vikings are the best answer for pumping many liquids—from viscous or thick semi-solids to light, liquefied gases. With Viking Pumps, you have: Self priming —smooth, even flow—controlled capacity —positive action—no splashing or pounding—no spasmodic operation—no foaming or churning.

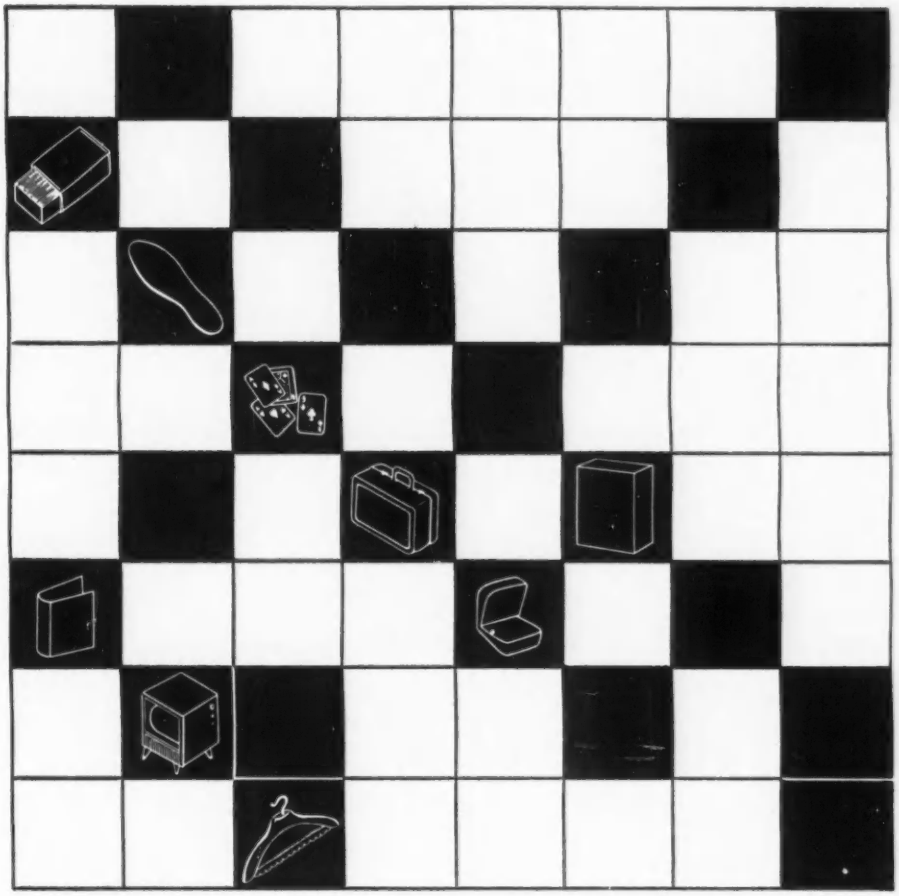
For information, call on your nearby Viking Pump distributor, or write for bulletin 57Sx.

VIKING — the leader, not a follower, in Rotary Pumps

VIKING PUMP CO.
Cedar Falls, Iowa, U.S.A.

In Canada, it's "***ROTO-KING***" pumps

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE



help solve the puzzle of product design...

WITH BOXBOARD BY GAIR!

This versatile material fabricates into almost any shape and lends itself to many new uses. In addition to making superior folding cartons and set-up boxes, Gair Boxboard excels as book covers, game boards, shoe innersoles, shelving, coat hangers, templates, chair seats, luggage boards, partitions, furniture and TV backs, and in dozens of other industrial and re-sale fabrications.

If you are designing a new product or improving an old one, Gair Technical Service will show you why it pays to create products and components with boxboard by Gair. Consistent high-quality in a great variety of grades, colors, coatings, laminations and treatments . . . fast delivery when and where you need it. Call your Gair representative or write Gair, today.

GAIR *boxboard*

SPRINGBOARD TO MORE SALES.

BOXBOARD AND FOLDING CARTON DIVISION OF CONTINENTAL CAN COMPANY

530 FIFTH AVENUE, NEW YORK 36, N. Y.

NOs for News

Our Laminum Shims are good news for thousands of metal working plants, because our "NOs" save time and reduce costs.

LAMINATED SHIMS OF

LAMINUM®
SURFACE BONDED... THEY *peel* FOR ADJUSTMENT

And *only in Laminum* are laminated, surface-bonded shims available *in all four materials* as shown below.

Laminated Shims of **LAMINUM** now available in

STAINLESS STEEL with laminations of .002" or .003"	**LOW CARBON STEEL** with laminations of .002" or .003"
BRASS with laminations of .002" or .003"	**ALUMINUM** with laminations of .003" only

LAMINATED SHIM COMPANY, INC.
Shim headquarters since 1913
1410 Union Street, Glenbrook, Conn.

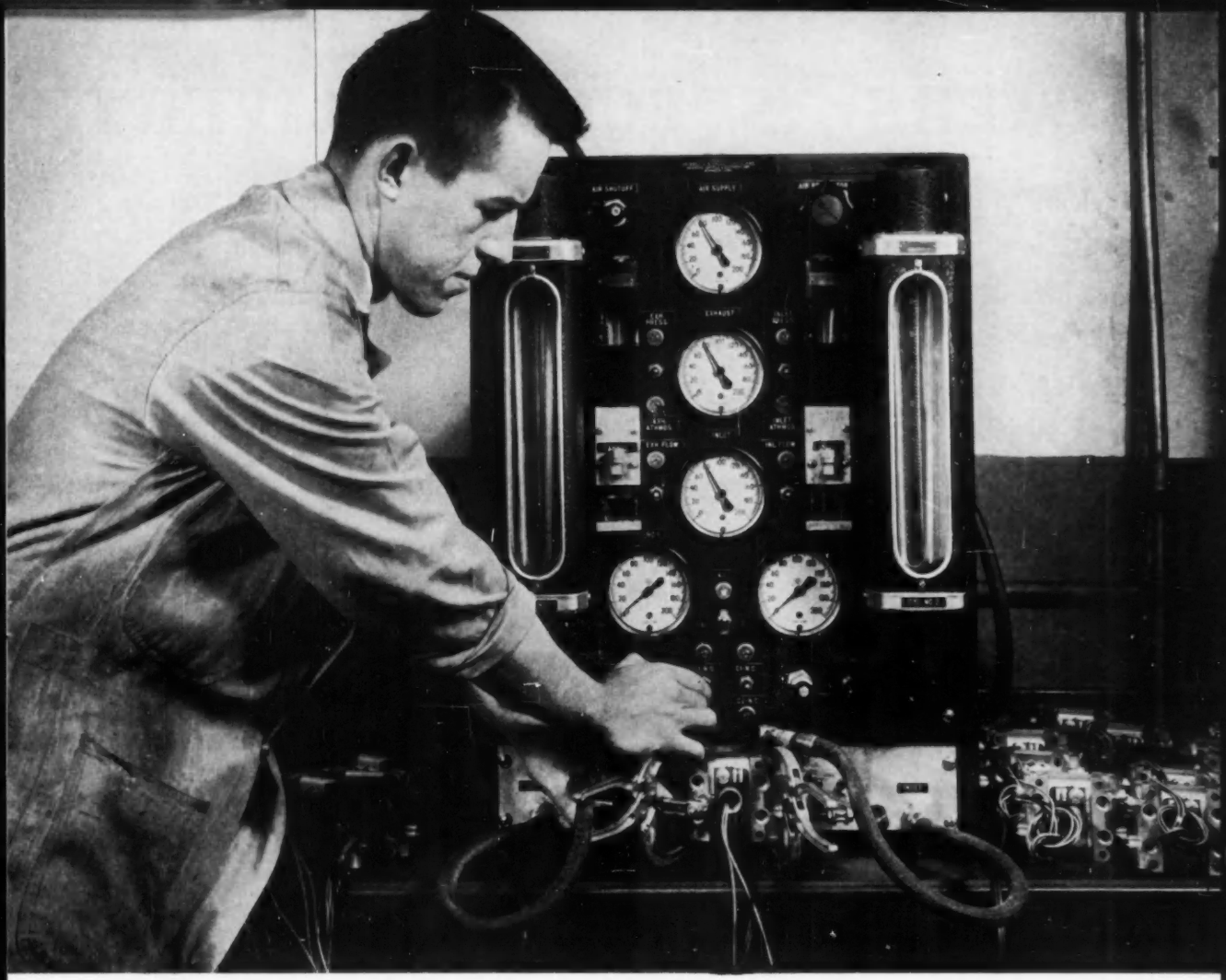
wearing qualities. Unit measures $1\frac{7}{8}$ in. OD, with a $1\frac{3}{8}$-in. pitch dia. Shaft bores of $\frac{1}{4}$, $\frac{5}{16}$ and $\frac{3}{8}$ in. are available. Weight is less than 3 oz. Used in drive mechanisms for instruments and servo systems, business machines, aircraft devices and similar applications. **Rampe Mfg. Co., 14915 Woodworth Ave., Cleveland 10.**

For more information—
Circle 43, inside back cover

Indoor, Outdoor Time Switches . . .

feature a 24-hr dial that can be used for as many as 12 on-off operations in a single day, with trippers set as close as 1 hr apart. Indoor model is designed with double or single-pole contacts. Capable of withstanding 350-amp inrush current. Outdoor model, with heavy-duty case, is for all types of outdoor lighting, capacitor switches, heating, irrigation and pump control. An omitting device is available for skipping a day or more of operation. DPST or SPST or SPDT switching arrangements are available. Contact rating is 35-amp tungsten load at 240 v; 60, 50 and 25 cps. Operates in temperatures from —20 F to 150 F. Devices use a 4-w motor. Indoor switch weighs $3\frac{1}{4}$ lb net and is $7\frac{3}{4}$ x 5 x $3\frac{1}{2}$ in. Out-

(Continued on page 142)



The 100% testing of all Skinner Solenoid Valves is your guarantee of consistent leakproof life

Every single Skinner Solenoid Valve receives 100% leakage inspection before shipment. Each one is tested under full pressure conditions at every point for both internal and external leakage. Modern, sensitive equipment like that shown above is used to quickly detect any defect.

In laboratory tests Skinner valves are regularly getting over 20 million cycles without leakage. And these remarkable results are constantly proving out in service.

In vacuum service, for example—and in critical test equipment—standard Skinner valves are frequently specified because of their record for outstanding trouble-free performance.

So, if you are looking for solenoid valves with exceptionally long leakproof life, look to Skinner valves. For complete information on Skinner's line of 2-, 3- and 4-way valves, write us or contact a Skinner representative. Write Dept. 450.

Skinner Solenoid Valves are distributed nationally

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION

NEW BRITAIN CONNECTICUT

105 EDGEWOOD AVENUE

TIMERS...SPECIAL DELIVERY

Standard or special— Industrial Timer makes rapid deliveries on all models

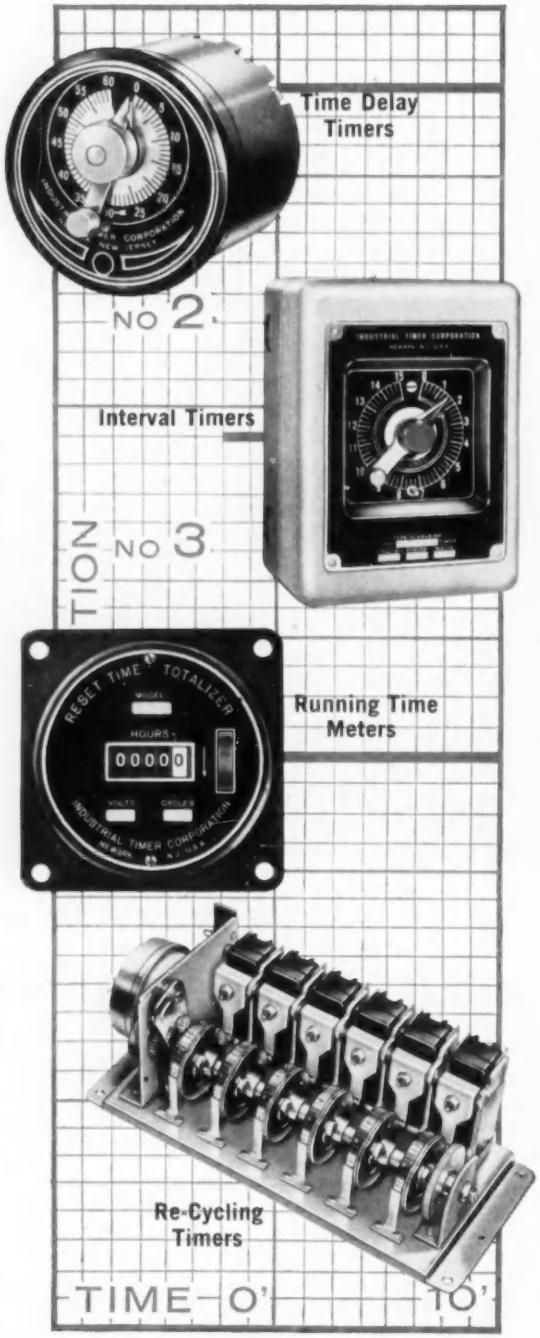
Sometimes you need a standard model timer . . . other times you need a special. Either way we can give you the extra rapid service you may need because of the efficient way we design, manufacture and stock timers for industrial applications.

To meet *all* of the widely varying needs of our customers we manufacture a complete line of timers in the four broad classifications illustrated here:

1. TIME DELAY TIMERS
2. INTERVAL TIMERS
3. RE-CYCLING TIMERS
4. RUNNING TIME METERS

From these we have already developed 20 basic types which can be combined in endless number of ways . . . to date, our engineers have combined them into over 1000 different models. So what might seem to be a special timer requirement to you, will very often be a standard timer in our large stock, and that is the reason we have the ability to fill special orders so quickly. And as far as standard timers are concerned we can give overnight service if necessary.

So, for the utmost in all-round service depend on us for this outstanding combination: deliveries "Immediate on Standards . . . First on Specials".



Speed up your automatic control projects— profit by our timing application experience

No need to let timing problems delay you in your automatic control projects when you can place them with us and get faster solutions. Even though no two automatic control jobs are ever exactly alike, and even though the timer requirements of each are very different we have established an excellent record in helping out in these situations.

20 years of experience in analyzing complex timer applications has provided us with the special knowledge required to give our customers the right answer in near-record time.

Our large stock of standard and combination timers enables us very often to fill orders for these requirements without any time loss because we have already developed so many new combinations specifically for automatic control functions.

Extra special automatic control timer — this calls for original designing. Our engineers will go right to work and get the job done. That's the way we grow and we like it.

Whatever your control problem, you have everything to gain by submitting it to our timer specialists. They'll come up with the answer — almost with the speed of automatic control itself.

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

INDUSTRIAL TIMER CORPORATION

1415 McCARTER HIGHWAY, NEWARK 4, N. J.

WEBSTER'S NEW PILOT OPERATED RELIEF VALVE

Compact design adapts to "tight" installations. Adjustable from 500 to 2000 psi. Maximum capacity, 20 gpm.

BOOSTS WORK OUTPUT 38.5%!

call the man from Webster

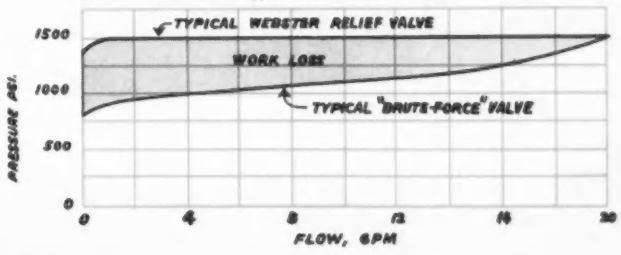
His intimate knowledge of this new relief valve — its many benefits and applications — can help in adapting it to your product.

Full speed power up to 93% of relief setting is now possible with this new Webster pilot operated relief valve. Result: 38.5% work bonus over "brute-force" type valves! More, you get all the benefits of clog-free performance, quieter operation...lower price. Mighty sound reasons for specifying Webster's pilot operated relief valve *now*.

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC
MELROSE 3-3511
RACINE · WIS

Typical performance curve shows minimum pressure drop and instantaneous response of Webster pilot operated relief valve over "brute-force" type. 38.5% work bonus!



- ☐ *Have THE MAN FROM WEBSTER contact us—*
  —Please send the following:
- ☐ *Bulletin HSA2 covering the new Webster pilot operated relief valve*
- ☐ *Complete hydraulic catalog of pumps, valves and fluid motors*
- ☐ *New information or data as published*

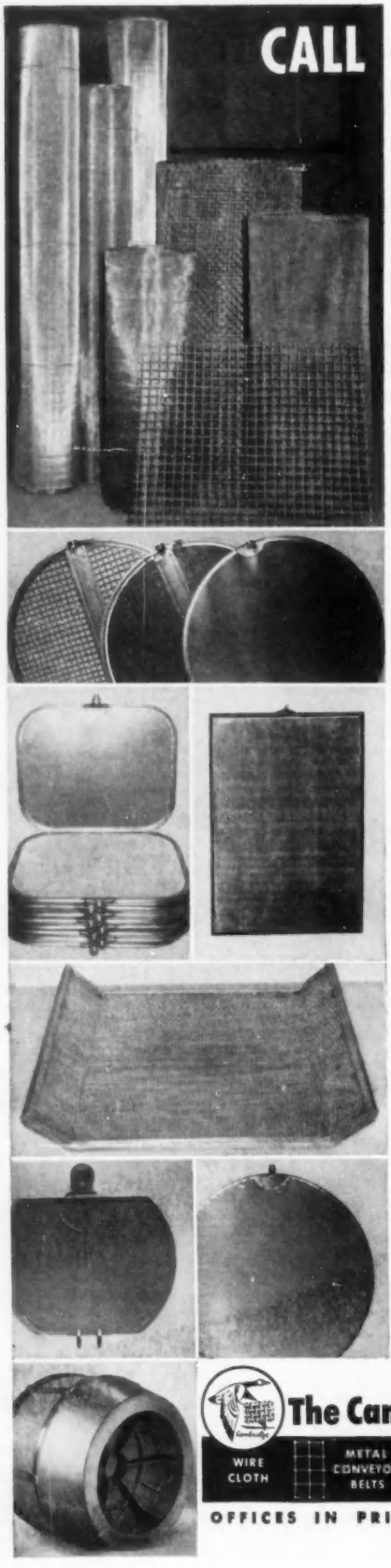
Name_____

Title_____

Company_____

City_____ State_____

franklin adv. H104



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INDUSTRIAL WIRE CLOTH

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FABRICATED PARTS

COMPLETE LINE

Nine weaves ranging from the finest to the coarsest, in any metal or alloy.

ACCURATELY WOVEN

Individual loom operation and careful inspection just before shipment assure accurate mesh count and uniform mesh size.

PROMPTLY DELIVERED

Most bulk orders are shipped immediately from stock. If your needs are for less frequently used types, we'll schedule our looms to fill your order without delay.

In fabricating parts . . . filter leaves, strainers, sizing screens . . . we'll work from your prints or draw up prints for your OK.

LET US QUOTE on your next order for wire cloth. Call your Cambridge Field Engineer—he's listed under "Wire Cloth" in the Yellow Pages of your 'phone book or write for FREE 80-PAGE CATALOG and stock list.

The Cambridge Wire Cloth Co.

WIRE CLOTH | METAL CONVEYOR BELTS | SPECIAL METAL FABRICATIONS

Department P, Cambridge 10, Maryland

OFFICES IN PRINCIPAL INDUSTRIAL CITIES

door model weighs 3¾ lb net and is 9$\frac{13}{32}$ x 6$\frac{5}{32}$ x 4$\frac{11}{32}$ in. **General Electric Co., Schenectady 5.**

For more information—
Circle 44, inside back cover

Custom Gaskets and Shapes . . .

from ¼ in. to 5 ft OD can be cut from rubber, neoprene, chemigum, butyl, PVC or sponge. **Central States Industrial Supply Co., Room 535, Terminal Tower, Cleveland 13.**

For more information—
Circle 45, inside back cover

Dime-size Potentiometer . . .

withstands temperatures up to 125 C, weighs 10 g and measures ½ x ½ in. Has high hermetic resistance because of an O-ring seal and glass-sealed header. Can be solder-mounted. Resistances to 75,000 ohm. **General Scientific Div., San Fernando Electric Mfg. Co., San Fernando, Calif.**

For more information—
Circle 46, inside back cover

Assorted Springs . . .

selected and packaged for experimental purposes include music wire, beryllium copper, high-nickel alloys. Selection based on analysis of common needs. **California Spring Co., Inc., 8401 E. Slauson Ave., P.O. Box 22014, Los Angeles 22.**

For more information—
Circle 47, inside back cover

Servoamplifier . . .

drives pneumatic or hydraulic servovalves in power servo applications. The five-tube

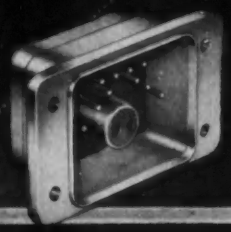
(Continued on page 144)

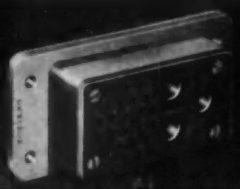
H. J. Reichel

RELIABLE

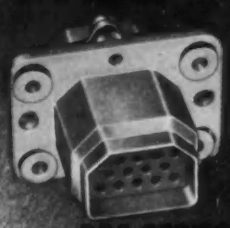
Rack-Panel-Chassis Connectors for RAPID DISCONNECT

Faster Inspection... Faster Testing...
Faster Servicing... Maximum Interchangeability





Cannon offers you more than 18 different basic designs in rack-panel-chassis connectors... designed with all the latest features to give you accurate alignment, easy mating, proper connection, and interfacial sealing where desired.



Select the connector you want in standard, miniature, or sub-miniature sizes... for standard circuitry or printed circuitry. Up to 156 contacts... and a great number of combinations of contacts for control, audio, thermocouple, co-ax, twin-ax, and pneumatic connections. In single- or double-gang. Some with shells, some without... all ruggedly constructed to take the many "in" and "out" operations of rack, panel, chassis, and sub-assembly applications. Special moisture-proof types. Standby units featuring gold-plated contacts to withstand deterioration and corrosion.

DPS SERIES

D SERIES

For an interesting discussion of the broad subject of "Reliability," write for Cannon Bulletin R-1.

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, California. Factories in Los Angeles, Salem, Mass., Toronto, Can., London, Eng., Melbourne, Austl. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities. **Please refer to Dept. 106.**

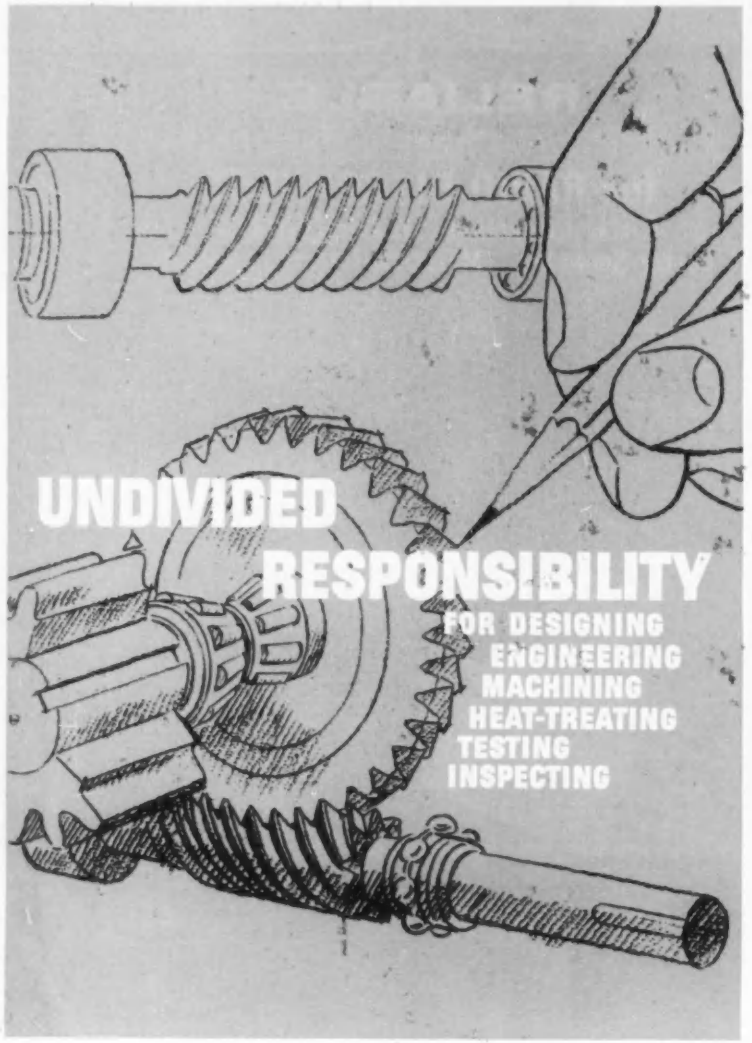
CANNON ELECTRIC

For **reliability** in your rack-panel-chassis connectors... connect with Cannon! Write for Bulletin DP-10 and DP-101 Supplement.

CANNON PLUGS

WHERE RELIABILITY IS THE 5TH DIMENSION

AWARENESS OF PROBLEM · INTEGRITY OF INTENT · DESIGN EFFORT · MANUFACTURING CONTROL



BRAD FOOTE Gears will perform satisfactorily when used in your shop —or on equipment you sell to others—because BRAD FOOTE can unconditionally guarantee their quality.

Every manufacturing step from the inception of the original design to delivery of the finished gears—including heat-treating—is completely controlled—here—in our own plant.

No one shares our responsibility.

BRAD FOOTE makes any type of gear—out of any type of material. BRAD FOOTE makes speed reducers, transmissions and intricate power units. All are famous for long, satisfactory service.

Why not discuss your requirements with our engineering staff, let us make recommendations or quote on your specifications. It can cost you much more to settle for less than BRAD FOOTE quality and service.

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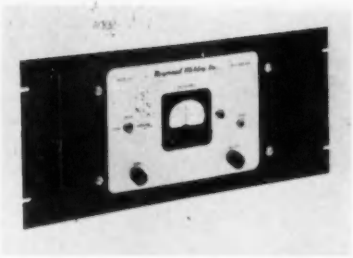
Phone: SPalding 1-4600
Pittsburgh 25, Pennsylvania



unit has dc or ac inputs, 60 cps excitation for feedback elements, panel meter for monitoring system performance, provision for plug-in compensating networks to alter servo system dynamic response when required. Produces a dc differential current, in the push-pull output stage, proportional to the input signal. **Raymond Atchley, Inc., 2340 Sawtelle Blvd., Los Angeles 64.**

For more information—
Circle 48, inside back cover

Simplified Circuit Switching Device . . .

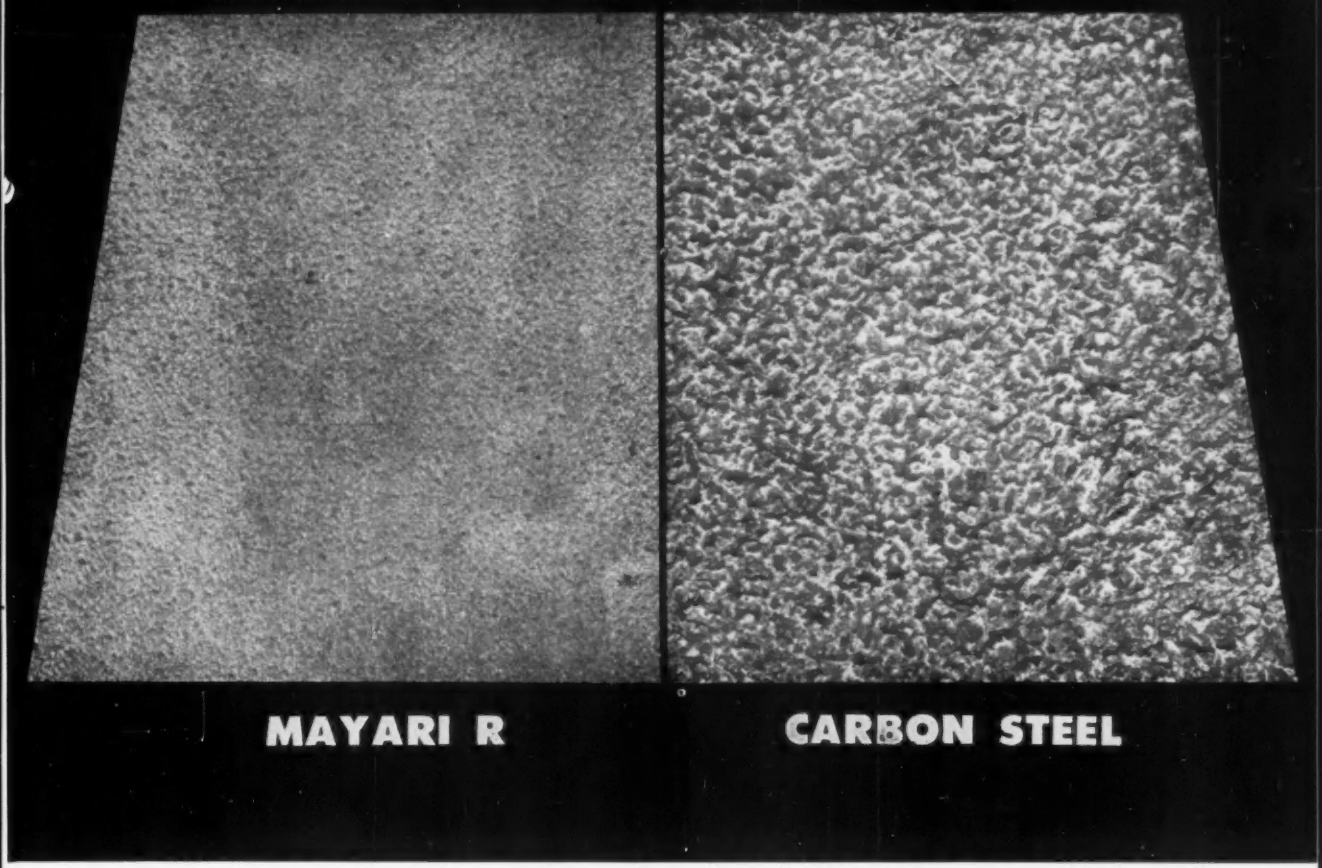
provides a substitute for patch card panel systems used in the changing of circuit connections at random intervals. A molded block has 400 floating contacts passing from one face to the other. Block is sandwiched between two printed wire boards having strip conductors in various grill-like formations. Contacts make connections between groups of conductors on one board to groups on the other, except where a card interposes insulation. Perforations in the card permit connections to be made where desired and to be changed by substituting a new card. The cards, 3 x 5 in., are contained in a 20 x 20 in. array. Facilities for perforating the cards as required are to be made available. **Cinch Mfg. Corp., 1026 S. Homan Ave., Chicago 24.**

For more information—
Circle 49, inside back cover

Ultrasonic Liquid-level Indicator . . .

shows true liquid levels in storage tanks and dewar vessels for corrosive chemicals, liquefied petroleum gases, liquid carbon dioxide, oxygen and all cryogenic liquids. Also indicates precise demarcation line between immiscible liquids. Liquid level is read directly in feet on a large meter with two ranges for tanks to 15 ft high. A built-in calibrator assures correct level-readings despite changes in velocity of sound because of varying temperatures, specific gravities and other such differences

(Continued on page 144)



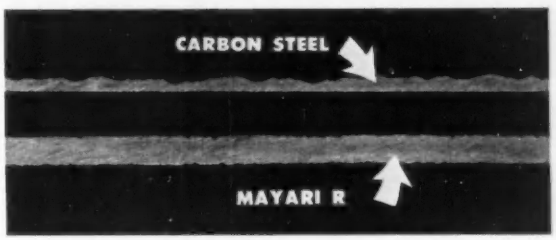
The test specimens as seen from above. After 5 years' exposure the Mayari R is relatively smooth while the carbon steel is deeply pitted.

See the difference after 5 years' exposure

You can see what corrosion has done to these steel sheets. One is plain carbon steel, the other is Mayari R high-strength, low-alloy steel. Originally, both were ⅛-in. thick. They were exposed together in industrial atmosphere for 5 years. During this period the carbon steel sheet lost so much through corrosion that it had to be replaced, but there was no appreciable loss of thickness in the sheet of Mayari R.

There is a simple reason why Mayari R has such excellent resistance to atmospheric corrosion. When this steel is exposed, a thin, tight layer of rust forms on the surface to act as a protective coating. This rust does not flake off in the manner of carbon steel rust. Instead it holds securely to the surface and retards further corrosive action. As a result, Mayari R has from 5 to 6 times more resistance to atmospheric corrosion than plain carbon steel, and from 2 to 4 times more than copper-bearing steel.

Mayari R also has other advantages. It has a higher yield point and greater tensile strength than ordinary carbon steel, and better resistance to many kinds of abrasion. It can be used to save steel, to reduce surplus deadweight, and to increase service life. Write or call the nearest Bethlehem sales office for further details.



This enlarged photograph shows cross-sections of a carbon steel sheet and a Mayari R Sheet after exposure.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

asg
UNIVERSAL JOINTS

available in 13 sizes with bored or solid hubs

You can get ASG Universal Joints directly from stock in 13 sizes with bored or solid hubs ranging in diameter from .375" to 4.000". Special bores, bores with keyways or setscrews are available upon special order.

ASG Universal Joints are ruggedly constructed of heat treated alloy steel. Matching or mating parts are precision ground to permit easy interchangeability of components. Self-locking retaining rings on small pins simplify assembly and disassembly. Joints of 7/8" length and longer have snap ball oilers. Smaller joints have oil holes. Oil enters at center of rotation to assure thorough lubrication of moving parts.

Send today for Bulletin No. 527 describing the full line of A.S.G. Universal Joints available from your nearest distributor.

AMERICAN STOCK GEAR DIVISION
PERFECTION GEAR COMPANY • HARVEY, ILLINOIS, U.S.A.

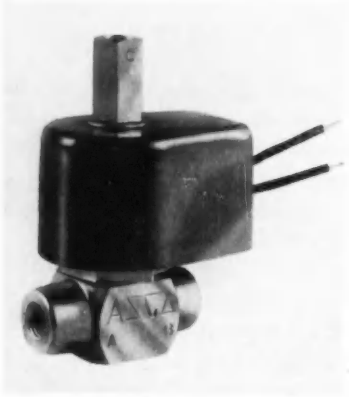
between liquids being gaged. One common indicator will gage as many as six transducer-equipped tanks within a radius of 1500 ft. The indicator is transistorized and consumes 5-w, 120-v, 60-cps power. **Bogue Electric Mfg. Co., 52 Iowa Ave., Paterson 3, N. J.**

For more information—
Circle 50, inside back cover

High-temperature Voltmeter . . .

withstands exposure to 85 C, maintaining 2% of full scale accuracy to 71 C. The vacuum-tube voltmeter uses a meter movement that weighs approximately 1 lb and takes no more panel space than a standard 3½-in.. meter. Input impedance is 1 megohm, frequency range is 20 to 50,000 cps. Available in any range from 30 mv to 300 v ac. Power required is 6.3 v and 125 to 200 v dc. **Trio Laboratories, Inc., 4025 Merrick Rd., Seaford, N. Y.**

For more information—
Circle 51, inside back cover

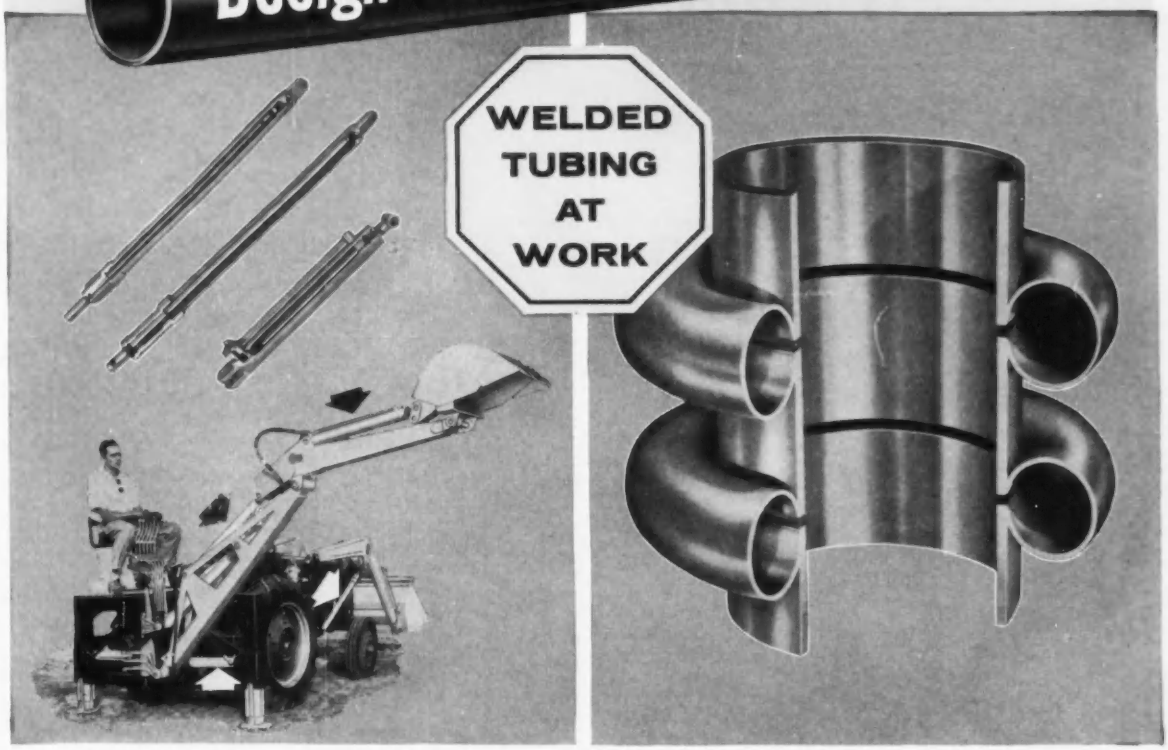


Three-way Midget Solenoid Valve . . .

with a pressure range of 0 to 300 psi is available in four constructions: universal type, normally closed (for air only), normally closed (air and liquids), and normally open (air and liquids). Offered are

(Continued on page 148)

Design with TUBING in mind!



The hydraulic cylinders operating this Back-hoe fabricate best from Welded Carbon Steel Tubing because of good honing characteristics, uniform roundness and concentricity.

Welded Stainless Steel Tubing formed into this packless expansion joint has served 15 years without failure at temperatures to 1800°F and pressures up to 10,000 psi.

When you need precision · strength · durability

CHOOSE WELDED STEEL TUBING

Carbon · Alloy · Stainless Steel

The uniformity of Welded Steel Tubing recommends it for the most exacting applications. When you need close fit, precise cross section and rugged durability your best answer is Welded Tubing. If your problem is heat, pressure, corrosion or uniformity of grain structure and surface, your best answer again is Welded Tubing. For all tubing applications, consult a quality tubing producer.

An Association of Quality Tube Producers

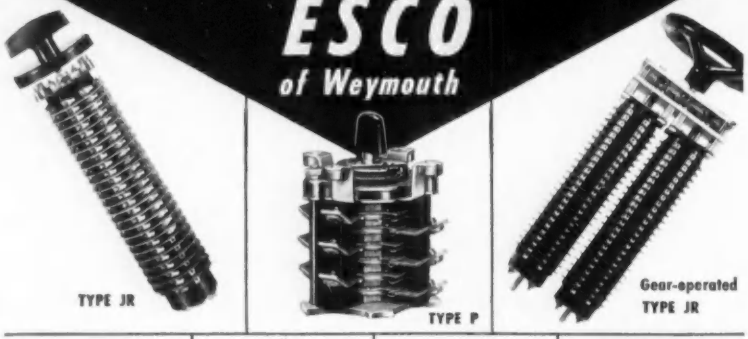
FORMED STEEL TUBE INSTITUTE — FSTI

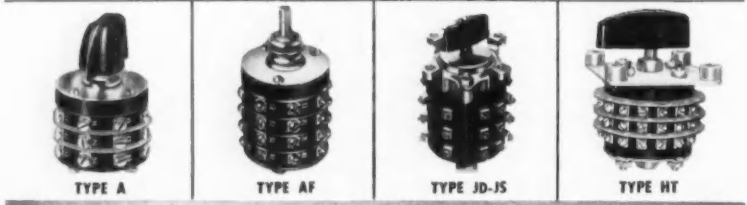
Design inspiration for you

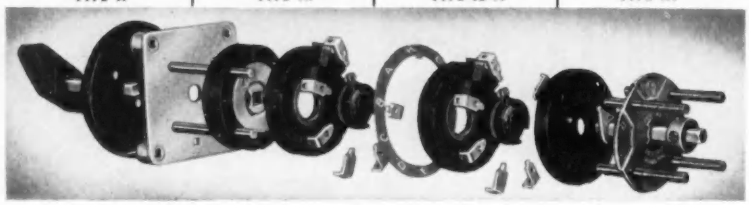
The 260-page Handbook of Welded Steel Tubing contains inspiration and data for tubing designs. For your copy, write on your company letterhead, giving your title.

FORMED STEEL TUBE INSTITUTE
850 HANNA BUILDING • CLEVELAND, OHIO

SPECIAL SWITCHES are STANDARD with ESCO of Weymouth







When you need a SPECIAL switch . . .

ESCO standard, uniform components can be assembled to meet your requirements; or a deviation from one of our standard types will give you a special switch at a standard switch cost. *Over 90% of our production is SPECIAL in one way or another.*

These standard switches can be modified to fit your application:

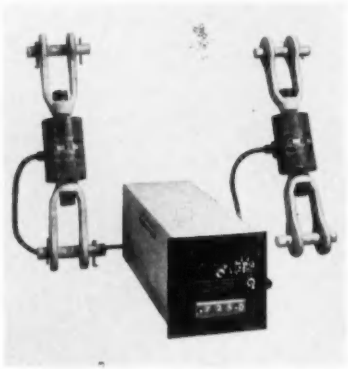
- **TYPE A** — up to 8 positions, 7 sections maximum, detent-mechanism, rating 5 amperes — 125 volts a-c/30 volts d-c.
- **TYPE AF** — up to 8 positions, 6 sections maximum, detent-action, rating with resistive load 5 amperes at 28 volts d-c or 115 volts 400 cps, per MIL-S-6807.
- **TYPE P** — Multi-section, up to 4 positions, snap-action, rating 10 amperes — 125 volts a-c, 5 amperes — 125 volts d-c, 30, 60, 100, 200 amperes at 500 volts a-c, or 250 volts d-c. Can be assembled to meet Specification MIL-S-15291.
- **TYPE JR** — up to 8 positions, 30 sections maximum, detent-action, rating 10 amperes at 125 volts a-c, 5 amperes 125 volts d-c.
- **TYPE JD-JS** — up to 8 positions, 5 sections maximum, detent-action or snap-action, rating 30 amperes at 230 volts a-c.
- **TYPE HT** — up to 16 positions, 6 sections maximum, detent-action, rating 5 amperes at 125 volts a-c.
- Bureau of Ships No. 9000-S6202-74085 rating 10 amperes at 120 volts a-c. BuShips 9000-S6202-74090, 9000-S6202-74096, and 9000-S6202-74224, ratings 30, 60, and 200 amperes, 500 volts a-c — 250 volts d-c.

Write for data sheets or catalog on ESCO rotary multipole switches — or send us your requirements and we'll give you full specifications on the ESCO switch that meets YOUR need.

ESCO of WEYMOUTH
ELECTRO SWITCH CORPORATION
Weymouth 88, Massachusetts

¼-in. and ⅛-in. pipe connections. Brass or stainless steel bar-stock bodies and crown-type seats, integral with valve bodies, supply inherently perfect seat alignment without leakage. Valves operate in any position on 550-v ac, 25-cps or 250-v dc. Packless construction has one moving part. **Automatic Switch Co., Florham Park, N. J.**

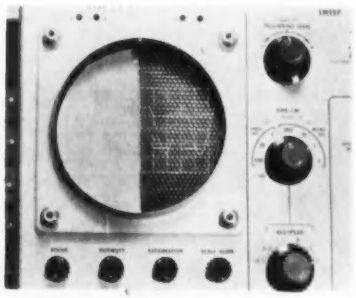
For more information—
Circle 52, inside back cover



Digital Weighing System . . .

determines center of gravity of missiles and similar objects. It employs two load cells feeding into a digital-reading weight indicator. Load cells contain strain-gage pickups. Accuracy is said to be 0.1%. Digital indication is provided by a continuous-balance electronic potentiometer. A servo-motor drives the precision number wheels. **Performance Measurements Co., 15301 W. McNichols Rd., Detroit 35.**

For more information—
Circle 53, inside back cover



Oscilloscope Accessory . . .

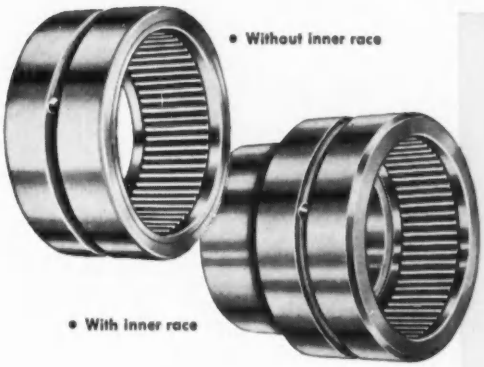
ends need for subdued light or hood when the instrument must be used in a bright environment. The device is a thin screen that fits directly in front of scope face and blocks off ambient light that blurs image. It consists of small, hexagonal openings that shut off glare, but permit full observation of image from

(Continued on page 150)

ORANGE NEEDLE BEARINGS

—offer widest choice of types and sizes to match your design needs

—greater opportunity to simplify design—fight friction—meet load requirements—save space and cost.



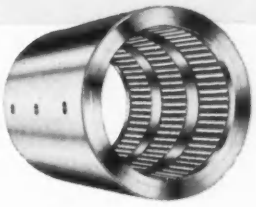
• Without inner race

• With inner race

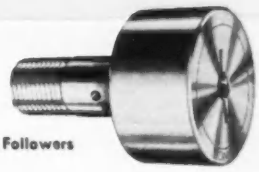
ORANGE *Full Type* ROLLER BUSHINGS

Maximum load capacity in small space

Orange Roller Bushings are full-type needle bearings for heavy-duty service. Rollers and races made of finest bearing steel—hardened, ground and finished to highest precision standards for durable, friction-free operation. Exacting control of roller uniformity by electronic gauging, permits closer internal running clearances, minimizing possibility of misaligned rollers. Complete range of stock sizes from ½″ to 8″ shaft diameters.



• Two and three row types for extra heavy duty

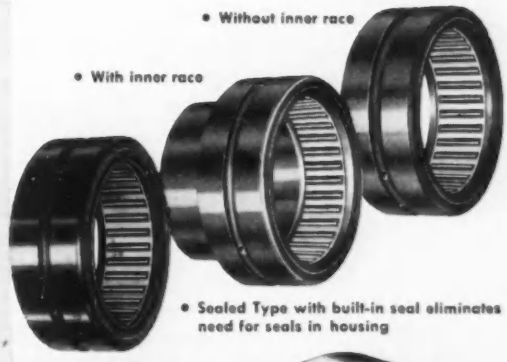


• Cam Followers

ORANGE *Cage Type* NEEDLE BEARINGS

Permanent alignment of rollers prevents skewing

Anti-friction cage keeps rollers permanently aligned and true-running in any position—vertical, tilted, horizontal. Successful on overhung mountings and relatively high-speed installations. Less affected by misaligned mountings or uneven loading. Extremely smooth, quiet running. The answer to many applications unsuited for conventional needle bearings. Wide choice of sizes from ½″ to 8″ diameter.

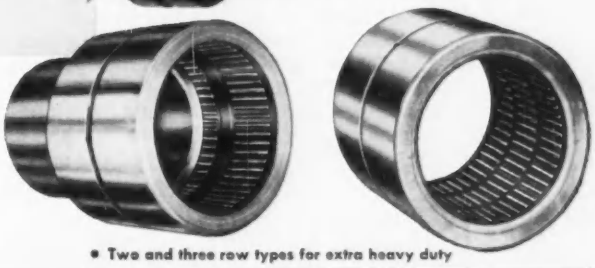


• Without inner race

• With inner race

• Sealed Type with built-in seal eliminates need for seals in housing

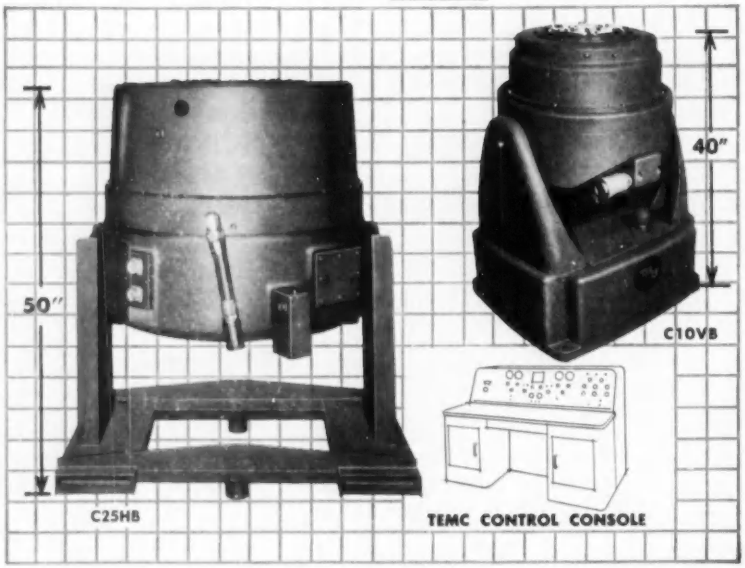
WRITE for new 40-page Engineering Reference Manual M-55 giving complete details of construction, dimensions, capacities, etc.



• Two and three row types for extra heavy duty

ORANGE ROLLER BEARING CO., INC., 551 Main Street, Orange, N. J.

FIGHT VIBRATION WITH VIBRATION



Vibration Testing cuts product development time

Testing components and structures with electrodynamic vibration exciter systems cuts research and development time in aircraft and missile systems. Often within hours, or minutes, the effect of service vibration can be pinpointed.

MB has perfected shaker systems that permit testing to all required specifications, enable engineers to speed product development from blueprint to prototype to production.

COMPLEX MOTION TESTING

Several MB Exciter Systems reproduce complex and random motions. They can subject products to the actual service vibration. The Model C10VB Shaker shown offers the widest frequency range for its force. Model C25HB provides higher forces for higher "g."

ENVIRONMENTAL TESTING

Both the above shaker systems can be used with environmental chambers . . . for "high altitude" and high or low temperature vibration testing. Oil cooled, they don't affect chamber vacuum.

SPECIFICATIONS

MB C10VB System provides . . .
10 "g" on table loads to 145 lbs.
20 "g" on table loads to 57.5 lbs.

Force output:	Band width:
1750 lbs. Sine	5-5000 cps
1050 lbs. RMS	15-2000 cps
3150 lbs. Peak	15-2000 cps

MB C25HB System provides . . .
10 "g" on table loads to 422 lbs.
20 "g" on table loads to 172 lbs.

Force output:	Band width:
5000 lbs. Sine	5-2000 cps
3500 lbs. RMS	15-2000 cps
10,500 lbs. Peak	15-2000 cps

In meeting your requirements, MB offers you advanced designs . . . plus quality construction of shaker, amplifier and control system . . . plus an experienced field service organization.

MB manufacturing company

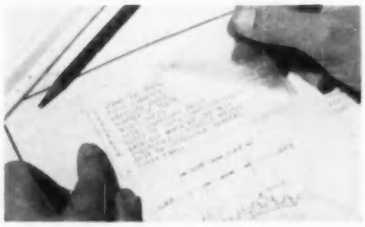
A DIVISION OF TEXTRON INC.

1076 State Street, New Haven 11, Connecticut

HEADQUARTERS FOR PRODUCTS TO ISOLATE . . . EXCITE . . . AND MEASURE VIBRATION

any point within 45° of face-on position. Tests indicate that under adverse lighting conditions, contrast is increased by factor of 20:1. Available to fit any standard 3 or 5-in. oscilloscope. **Van-Dee Products, 300 Ocean Ave., Laguna Beach, Calif.**

For more information—
Circle 54, inside back cover



Drafting Applique Material . . .

adheres to drawing paper, even after long periods of storage. The transluscent plastic has a fine grain surface that will take pencil, ink or printing. It becomes transparent on contact with the drawing paper. Available in sheet form with special backing in standard sizes of 6 x 9 in. and 8½ x 11 in., plain or printed to specifications. **Transparent Products Co., Inc., Aplika Dept., 324 E. 24th St., New York 10.**

For more information—
Circle 55, inside back cover

Cadmium-plated Steel Flinger . . .

avoids build-up of foreign matter against rubber seals and permits using self-lubricated units under dirty and wet-operating conditions. Also, runover of lubricant from self-lubrication bearings during initial running period is retained in cavity of the flinger to form additional sealer. **Rockwood Pulley Mfg. Co., Inc., 20 Crosby St., New York 13.**

For more information—
Circle 56, inside back cover

Large-scale Drawing Board . . .

is 12 ft long, has special drafting tools for producing enlarged master artwork for printed-wiring boards. The 1-in. maple

(Continued on page 154)

premium on purity

From the cow to the container, the purity and delicate flavor of dairy products must be protected. Dairy equipment made of stainless steel resists corrosion, imparts no odor to the product and is easy to keep clean and sterile. The highest quality dairy equipment is designed, improved and protected with McLOUTH STAINLESS STEEL.

specify

McLOUTH STAINLESS STEEL

HIGH QUALITY SHEET AND STRIP

for the dairy industry

McLOUTH STEEL CORPORATION DETROIT, MICHIGAN

MANUFACTURERS OF STAINLESS AND CARBON STEELS

HOWELL MOTOR BRIEFS

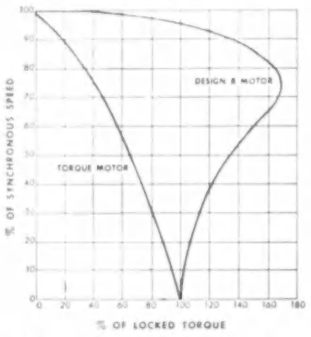
Quick facts for those who apply and specify electric motors

Torque Motors: *They Stall and Hold*

If you want a machine drive to not only apply power but also hold a position or maintain a constant tension, a Howell torque motor may be your solution. Here's a motor that can be stalled, while exerting maximum torque for predetermined intervals, without burning out . . . that can also apply virtually constant torque while operating at a given sub-synchronous speed.

Linear Speed-Torque Curve

The graph below shows this motor's almost linear speed-torque characteristics as compared to a conventional motor's. The secret lies in the design, which produces increased torque while limiting locked rotor current.

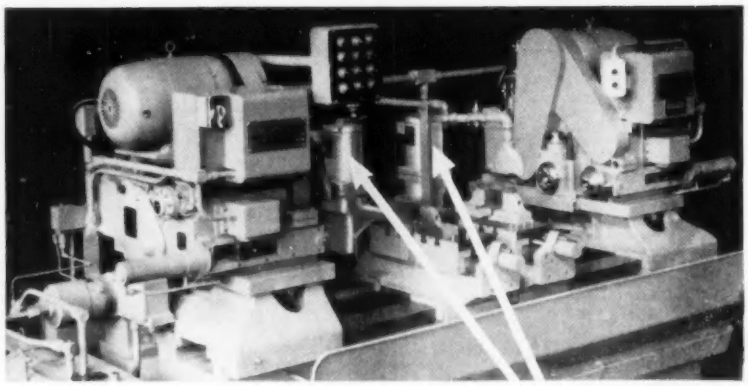


Adaptable to Many Uses

In addition to the clamping, elevator drive and reel tension applications shown at right, Howell torque motors are doing a great many other jobs. Door opening and closing, take-up reeling of film and carbon paper, activating electrical starter contacts and a variety of clutching, chucking and braking operations are among them. They do a quieter, more positive job than many mechanical devices and can often effect important simplifications in machine design.

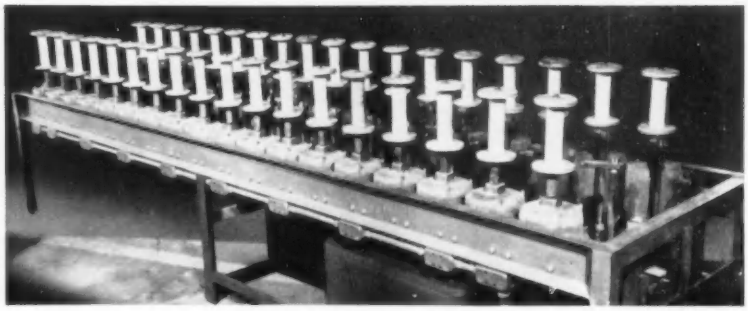
Typical Howell Series 100 Torque Motor

Write us details of *your* requirements. We'll be glad to make suggestions and a quotation.



Two Howell Torque Motors operate clamps for positioning and holding the workpiece on this high-speed, automatic milling and centering machine. Seven Howell motors in all provide power for this precision operation.

A Howell Torque Motor operates the brake and the elevator driving mechanism shown at right. Opening and closing of elevator doors is another typical torque motor application.



A constant, precise tension is maintained on monofilament plastic thread, after extrusion, by the 36 Howell Torque Motors on this winding machine. Multi-speed reeling and winding operations, particularly, are simplified by the use of torque motors in place of geared mechanical devices that are relatively expensive and difficult to keep in adjustment.

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

"You can form dies 4 times faster with Formica S-52 die stock"

S-52 aircraft die used by Twin Coach Corp. for forming this beaded skin airplane wing part. It is machined to a tolerance of .005" and can easily be lifted by one man.

"We cut our die forming time from 4 months to 4 weeks when we switched from steel to Formica S-52 die stock," declares Stephen Chojnacki, general foreman, Aircraft Division plant, Twin Coach Corp., Buffalo.

"Twin Coach has been using Formica S-52 laminated plastics for over four years now, for pressing aircraft and coach parts. It's the most economical material we've ever used for this purpose.

"S-52 is easier to machine to close tolerances. It has a hard, dense structure that holds its shape. And its smooth surface never puts a pattern in the metal being formed."

Manufacturers interested in better, faster and cheaper forming of non-ferrous metal, plastic, wood, rubber, vulcanized fibre and other ductile materials — should check Formica S-52. Send today for your free copy of bulletin 604. Formica Corporation, subsidiary of American Cyanamid, 4516-7, Spring Grove Ave., Cincinnati 32, Ohio.

S-52 8 ways better than steel dies:

1. Faster, cheaper and easier to machine.
2. Easier to handle and move — it's light in weight.
3. Longer die life — some dies in use at Twin Coach for 4 years, withstand pressure up to 10,000 psi.
4. Rejects reduced from 50% with steel dies, to nothing with S-52 which prevents metal in dies from flaking off.
5. Takes deeper tooling — although easily machined, S-52 retains rigidity.
6. Prevents sticking, retains lubricant.
7. Eliminates tool drawings — die makers work directly from templates.
8. Offers more surface per pound per dollar

Save your engineers . . . . **use Formica 4 the complete laminated plastics service**

FORMICA 4

Subsidiary of CYANAMID

1. Application engineering **2. Research** **3. Fabricating** **4. Customer stock service**

FI-1422

PIC *Endurance Rated* Counters
to Fit every need

Super-Wizard Electric Counters

200 Million Count Life.

The real heavy duty electric counter—unapproached leader for over 25 years.

5 watts power consumption.

Quiet, no AC hum.

Available for all standard voltages and frequencies including DC.

Silver King Stroke Counters

The Toughest Stroke Counters

200 Million Count Life

Used in automobile and aircraft plants, stamping, metal working, die casting and plastic molding plants, and factories of all kinds.

PIC-600 Electric Counters

QUIET no AC hum

50 Million Count Life

Tested at 1000 CPM; reliable at much higher speeds with suitable actuation.

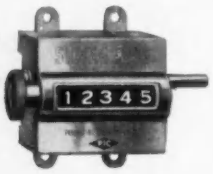
Only 7 watts power consumption.

Available for all standard voltages and frequencies including DC.

Silver King Revolution Counters

Rugged as a bull dozer.

Operate smooth as a watch.



200 Million Count Life

Used on measuring machines and coil winders, for revolution counting on engines, pumps, etc. and for tool registration.

Mercury Electric Counters

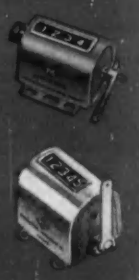
Small, compact counters for use where space is limited and duty is light to moderate.

Extensively used for laboratory service, also for built-in application on office machines, light industrial equipment, and vending machines of all kinds.

Knob Reset models rated 6 million counts, Non-Reset, 3 million.

Junior King Stroke Counters

Small, light to moderate duty mechanical stroke counters for use where space is limited and duty is light to moderate.



Widely used for laboratory service, also built-in application on office machines, light industrial equipment, etc.

Reset models have 6 million count life; non-reset models 3 million

See your PIC Distributor or send for the PIC catalog describing Electric Counters and Actuators; Mechanical Stroke and Revolution Counters; and electrically operated Automatic Batch Counters.

PIC *Production Instruments*
DIVISION OF GENERAL CONTROLS CO.
8072 McCormick Boulevard, Skokie, Ill.
manufacturers of counting instruments for every purpose

42 Branch Offices and Representatives serving USA and Canada

plywood board has an aluminum straight-edge mounted at the base. Drawing tools include 18-in.-long phenolic strips in 3, 6, 9 and 12-in. depths as ruling blocks. 12-in. parallel straight-edges modified with adjustable clamps provide horizontal ruling throughout length of the board. Vertical ruling is done with triangles positioned on the ruling blocks. **Electronics, Inc., of Penna., 39 York Rd., Willow Grove, Penna.**

For more information—
Circle 57, inside back cover

Motor-operated Hydraulic Valves . . .

provide shock-free, positive directional flow control. A cylindrical screw-type slide plunger is actuated by a 28-v dc motor-driven, two-stage gear train. Basic valve design gives two-way control, with ½-in. slide travel. Features one-piece valve body, automatic current shut-off, easy inspection and maintenance. Flow is 6 gpm; pressure drop is 9 psi. The 5.45-in.-long valve has a line size of ¼ in. Weight is 2 lb. Operates through ambient temperatures of —65 F to 160 F. **Lyndon Aircraft, Inc., 140-71 Clifford St., Newark, N. J.**

For more information—
Circle 58, inside back cover

Templets for Flanged Valves . . .

are made of 0.030-in. plastic, with all cutouts individually milled. One covers the B16.10 valves in a scale of ⅜ in. to 1 ft; the other, in scale of ¼ in. to 1 ft. Both include sizes from 2 to 8-in. pipe dia in light (125 to 150 lb) and heavy (250 to 300 lb) series. Price of each is $2.50. **Rapidesign, Inc., P. O. Box 429, Burbank, Calif.**

For more information—
Circle 59, inside back cover

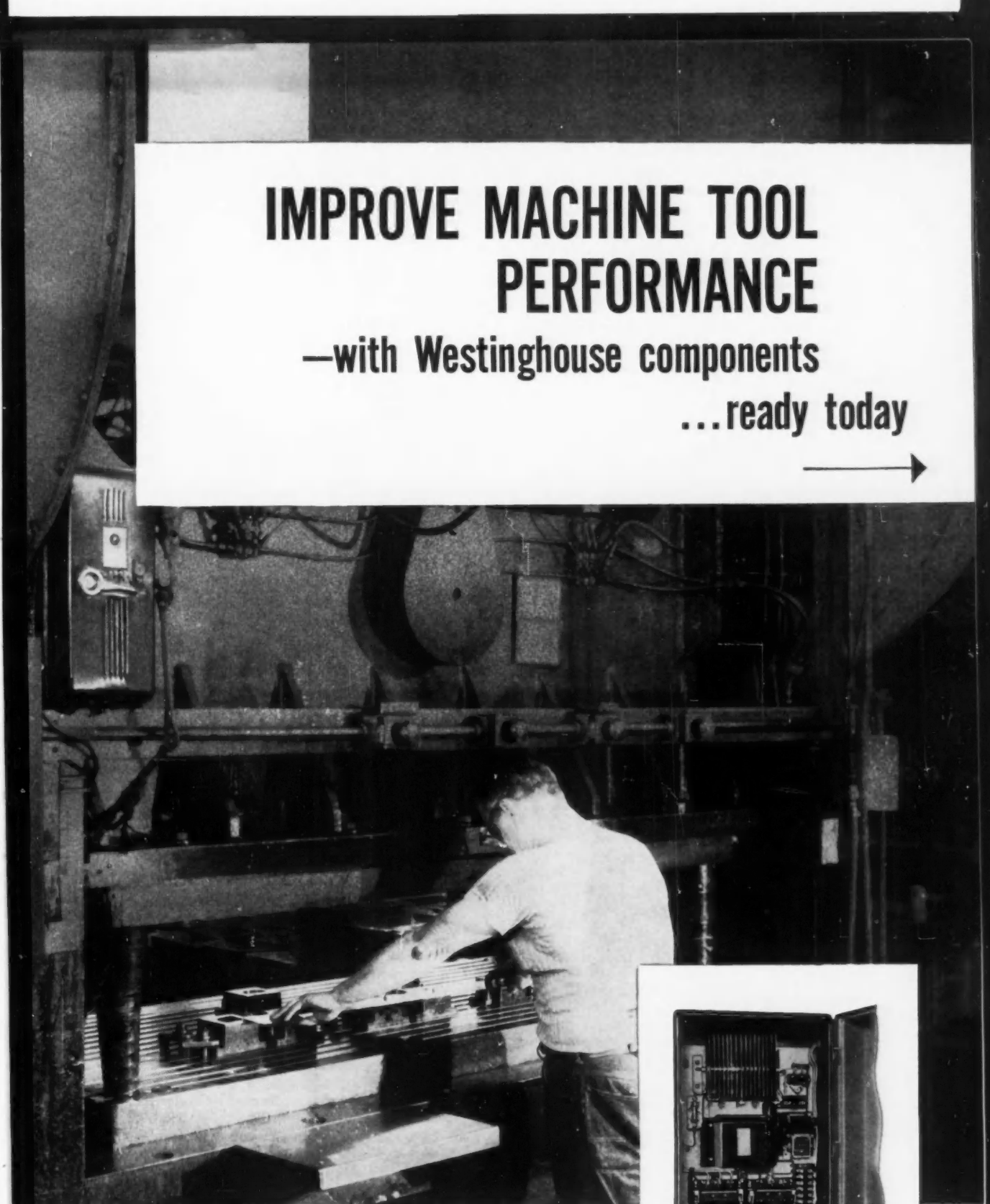
High-speed Whiteprinter . . .

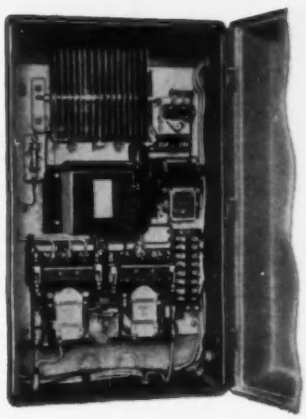
with 46-in. printing width, is equipped with a 5000-to-7500-w selective switch-controlled lamp, and adjustable lamp shield; has a machine speed of 75 fpm. Print production is said to be increased by as much as 250%. Wide printing latitude provides side-by-side feeding of small and medium-sized tracings which, after exposure, are automatically stacked in stacking tray. Prints, too, are automatically stacked. **Chas. Bruning Co., Inc., 4700 W. Montrose Ave., Chicago 41.**

For more information—
Circle 60, inside back cover

IMPROVE MACHINE TOOL PERFORMANCE

—with Westinghouse components ...ready today





Stamping press performance improved at this plant when they used Westinghouse DYNAC braking control to reduce stopping time 95 percent.

MP-3057-1

YOU CAN BE SURE...IF IT'S Westinghouse

Westinghouse Cypak static control reduces maintenance costs in form-grinding automotive transmission parts.

THESE COMPONENTS OFFER IMMEDIATE ANSWERS

...for more dependable operation
...for quicker stopping...for faster duty cycles

You don't have to wait for electrical answers in making machine tool improvements or modifications. Outstanding design and improvement in Westinghouse control components, systems and drives help designers and their customers to act now.

For example, *Westinghouse DYNAC® braking control*, cover photo, reduces press stopping time 95 percent. The eight minutes it previously took to stop the heavy flywheel on this press have been cut to just 24 seconds with DYNAC. This operation is now getting the fastest, smoothest stops possible to increase production.

Cypak static control*, above, has already outlasted conventional relays previously used on form grinders at a large automobile manufacturer's plant. No down time for control maintenance has been necessary on this highly repetitive operation in over 17 months.

*Trade-Mark

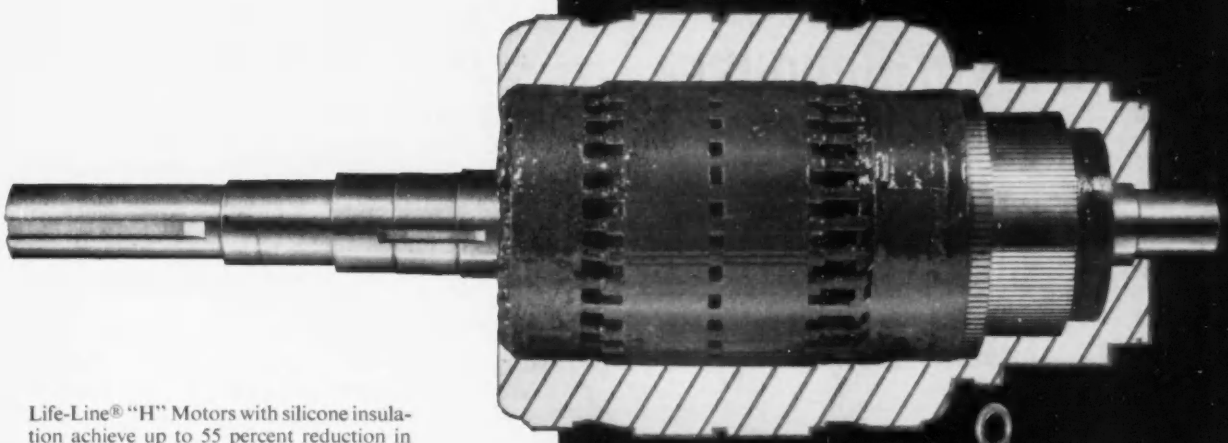
Westinghouse Life-Line® "H" Motors, right, make possible faster, smoother reversing cycles to save production time. Westinghouse reduced armature inertia up to 55 percent and increased commutating ability 35 percent to provide in the Life-Line "H" Motor the fastest d-c motor response available to improve machine tool performance.

Westinghouse right-angle gearmotor, right, delivers up to 195 percent more torque capacity than conventional single-reduction worm gearmotors between 9:1 and 60:1 speed reduction ratios. It's the result of more efficient, double-reduction gear train. You'll find Westinghouse packaged motor-reducer drives offer rugged dependability, too, for improved machine performance.

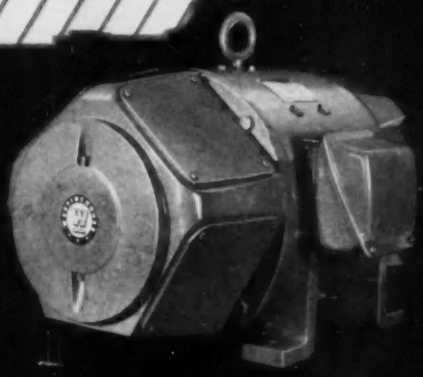
Developments like these help you design and build machine tools that answer your customers' needs for increased productivity at lower cost. Whatever the function you want performed . . . sensing, transmitting, recording, computing, control or driving . . . think of Westinghouse components first!

MP-3057-2

YOU CAN BE SURE...IF IT'S Westinghouse



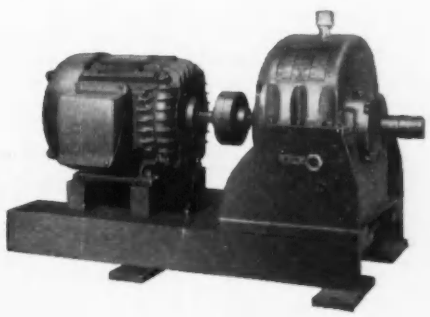
Life-Line® "H" Motors with silicone insulation achieve up to 55 percent reduction in armature inertia by reducing armature size, as shown by the silhouette above. New controlled ventilation system makes this reduction possible. With commutating ability increased 35 percent, the Life-Line "H" assures faster reversing performance.

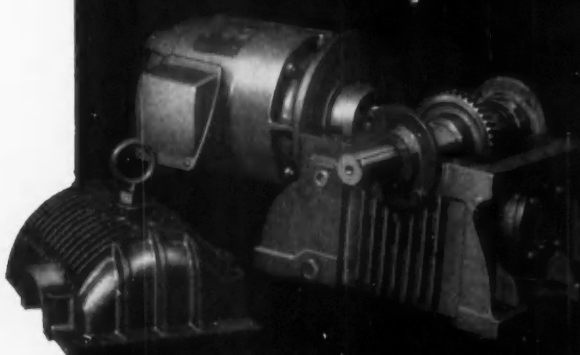


Push-lite pushbuttons combine the functions of both a pushbutton and indication light in one unit. One push transmits the signal and energizes the indicating light. Push-lites are oiltight — part of the complete Oil-Tite* line of 1,500,000 pushbutton control arrangements available from stock.

*Trade-Mark

Either Westinghouse gearmotors or packaged motor-reducer drives save design time with a wide selection in horsepower, speed ratios, direction of power take-off, mounting and coupling methods. MP-3057-3





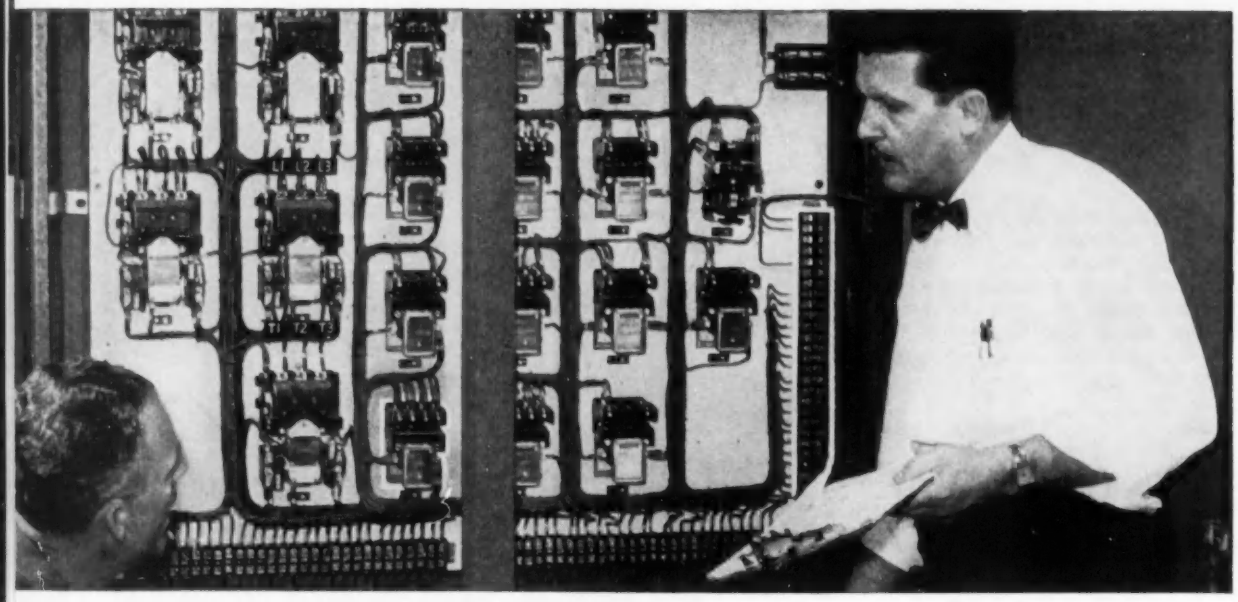
WESTINGHOUSE SERVICES AND FACILITIES ARE FLEXIBLE

HELP YOU FROM DESIGN BOARD TO TEST FLOOR

Add experienced manpower to your machine tool projects by simply calling your local Westinghouse representative. Whether you have a problem in drive system design, in component development or in manufacture and assembly, Westinghouse facilities provide economical ways to get the answer on schedule.

Westinghouse research . . . field engineering service . . . local manufacturing and repair plants . . . renewal parts stocks . . . are all ready to extend you service in any situation.

And when you select Westinghouse components, your customers will recognize electrical leadership. You'll benefit from one-supplier responsibility for products of outstanding quality, backed by more than 70 years of electrical experience. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania. MP-3057-4



YOU CAN BE SURE... IF IT'S Westinghouse

Westinghouse serves these O. E. M. industries

- Air conditioning
- Appliance
- Communications—electronic
- Electric apparatus
- Fan and blower
- Machine tool
- Materials handling
- Panelboard and switchboard
- Prime mover equipment
- Pump and compressor
- Miscellaneous machinery

. . . with these components

- Motors—gearmotors
- Adjustable-speed drives
- Gearing
- Controls—relays—circuit breakers
- Semiconductors
- Cypak*
- Magamp* magnetic amplifiers
- Rectifiers
- Heating elements—thermostats
- Transformers
- Instruments
- DYNAC® magnetic braking

*Trade-Mark

CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

COMPUTER ELEMENTS—Bulletin C-24, 8 pp. Manual describes transistor-equipped plug-in components and their applications. With schematic diagrams and specification data. Ransom Research, 323 W. 7th St., San Pedro, Calif.

Circle 61, inside back cover

ELECTRIC BRAKES—Report WEB 6293, 36 pp. Illustrated report on electric brake for fail-safe applications. Includes photos, drawings, cutaway and schematic diagrams, and explanation of operation, selection factors, torque characteristics and controls. Warner Electric Brake & Clutch Co., Beloit, Wis.

Circle 62, inside back cover

SMALL PLASTIC STOCK PARTS—Catalog 500A, 56 pp. 1957-58 edition lists over 1000 injection molded and extruded plastic parts available from open stock. Illustrated with dimensional and line drawings. Pipco International Corp., 1731 Stanford St., Santa Monica, Calif.

Circle 63, inside back cover

PLASTIC PROTECTORS—Bulletin P-5708, 18 pp. Illustrates, in two colors, line of plastic plugs and caps. Designs are described in individual sections with key specifications in table form. With dimensional drawings and installation pictures. S. S. White Plastics Div., 10 E. 40th St., New York 16.

Circle 64, inside back cover

AIR FILTRATION—Booklet, 8 pp. Specification data on filters, including installation, performance and construction information. Illustrated with diagrams, performance curves and tables. Flanders Filters, Inc., P. O. Box 718, Riverhead, N. Y.

Circle 65, inside back cover

MINIATURE BEARINGS—Catalog, 24 pp. Dimensional tables, drawings, photos, and specification data on bearing series. Also, a new section on duplex bearings. Information on applications, load ratings, limiting speeds, mounting, materials, inspection correlation, clearances, torque, lubrication, shaft and housing fits. Miniature Precision Bearings, Inc., Precision Park, Keene, N. H.

Circle 66, inside back cover

DUAL-OUTPUT LUBRICATOR—Reference sheet, 2 pp. Describes lubricator, operation and applications. Photographs and a drawing illustrate its internal mechanism. A chart gives discharge per cycle, discharge per hr, and time for 1-pt discharge with various cam settings and cycle times. Bijur Lubricating Corp., 151 W. Passaic St., Rochelle Park, N. J.

Circle 67, inside back cover

SELF-LOCKING THREADED PARTS—Manual, 4 pp. Explains self-locking principle and how it can be applied to any threaded part. Included are basic engineering recommendations, plus a check list for the design of threaded parts to take advantage of the process. Nylok-Detroit Corp., 1100 N. Woodward Ave., Birmingham, Mich.

Circle 68, inside back cover

WIREWOUND RESISTORS—Catalog, 8 pp. Includes charts, graphs, illustrations, drawings and specifications pertinent to the resistors and networks produced by: General Resistance, Inc., 577 E. 156th St., New York 55.

Circle 69, inside back cover

SERVO-MECHANICAL PARTS—Catalog, 32 pp. Describes and gives specifications for miniature and standard parts for prototype and production servos. With dimensional drawings, nomographs. Reeves Instrument Corp., 207 E. 91st St., NYC.

Circle 70, inside back cover

STEEL SHAFT COLLARS—Bulletin, 4 pp. Common applications, construction details, and specification information on the collars are discussed. Standard Pressed Steel Co., Box 545, Jenkintown, Penn.

Circle 71, inside back cover

PUMPS—Catalog 757, 16 pp. Gives details of construction, dimensions, capacities, performance curves and installations on rotary positive air and vacuum pumps, gas boosters and air motors. Leiman Bros., Inc., 102 Christie St., Newark 5, N. J.

Circle 72, inside back cover

SQUIB SWITCHES—Data sheet, 4 pp. Gives physical and electrical characteristics of these electrochemical switches. Weight, total actuation time, contact resistance and current capacity, contact bounce characteristics and dielectric strength of insula-

(Continued on page 162)

Worcester's New Econ-O-"Miser" Ball Valve* is BOTH

VALVE and UNION

The costs of a union and installing it are eliminated. Add to this the longer operating life of the Econ-O-"Miser", the time and materials savings of *in-line maintenance*, and you get performance unmatched by *any* valve at *any* price.

The Econ-O-"Miser" is available in Bronze, Aluminum, Aluminum Bronze, Forged Carbon Steel, types 303 and 316 Stainless Steel. Seat and seal materials available: Teflon, Buna-N and Neoprene (others available on request.)

The many combinations of body and seat seal materials allow handling of exceptionally wide range of media.

Other Outstanding Features

- Compact for ease of installation
- Positive leakproof shut-off
- **In-line maintenance** permits quick, easy inexpensive repairs
- Two-way flow allows application of pressure or vacuum to either side of valve
- Quarter turn operation — readily adaptable to remote control
- Visual determination of OPEN — CLOSED positions — No manual check needed
- Round flow through the valve — minimum pressure loss and turbulence
- "Wiper-action" of resilient seat against ball eliminates abrasive wear due to foreign materials in media . . . assures leak-proof seal . . . long operating life

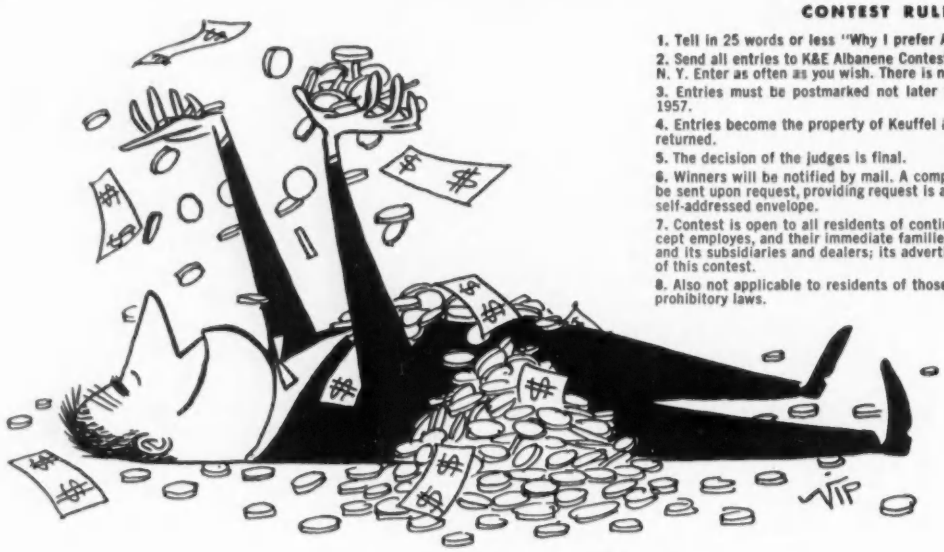
* Pat. Pending

Write for full particulars

WORCESTER VALVE CO., Inc.

18 Parker Street, Worcester, Mass.

ENTER THIS CONTEST ...90 CASH PRIZES!



CONTEST RULES

1. Tell in 25 words or less "Why I prefer Albanene tracing paper."
2. Send all entries to K&E Albanene Contest, Box 160, New York 46, N. Y. Enter as often as you wish. There is nothing to buy.
3. Entries must be postmarked not later than midnight, Nov. 30, 1957.
4. Entries become the property of Keuffel & Esser Co. None can be returned.
5. The decision of the judges is final.
6. Winners will be notified by mail. A complete list of winners will be sent upon request, providing request is accompanied by stamped, self-addressed envelope.
7. Contest is open to all residents of continental United States, except employes, and their immediate families, of Keuffel & Esser Co. and its subsidiaries and dealers; its advertising agency; and judges of this contest.
8. Also not applicable to residents of those states where there are prohibitory laws.

Why I prefer **ALBANENE**® Tracing Paper...

First prize $1500
Second prize $1000
Third prize . . . . . $ 500

plus 87 prizes of $25 each!

In 25 words or less, tell us why you prefer K&E Albanene® tracing paper. Your reasons may win one of these 90 prizes (it's K&E's 90th anniversary).

Here's a hint: Albanene is made from 100% rag stock for superlative tear strength. It is permanently transparentized with an inert resin. Draftsmen like it because of its easy drawing qualities . . . reproduction men for its high transparency and permanence. Everybody likes it because "what you pay for stays in the paper." That's why Albanene is the best seller among *all* tracing papers.

Get contest aids from your K&E dealer: Information booklets, extra contest entry blanks, samples of Albanene, too, if you need them. You can enter as often as you please.

Or use a plain sheet of paper if someone's already snipped the blank below. Give your name, address, and firm name, twenty-five words or less telling why you prefer Albanene tracing paper, and mail to K&E Albanene Contest, Box 160, New York 46, N. Y. before midnight, November 30, 1957.

KEUFFEL & ESSER CO.
New York, Hoboken, N. J., Detroit, Montreal, Chicago, St. Louis, Dallas, San Francisco, Los Angeles, Seattle.
Dealers in principal cities

K & E Albanene Contest, Box 160, New York 46, N. Y.

Here's why I prefer Albanene Tracing Papers_____

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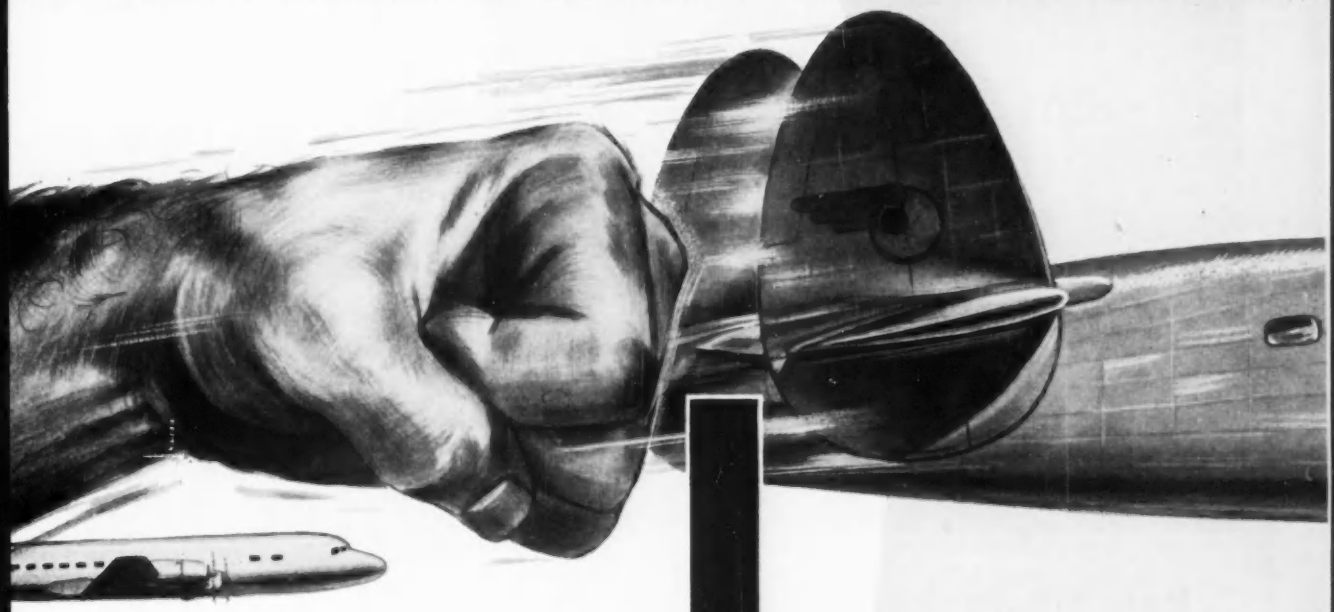
*Name*_____ *City*_____ *Zone*_____ *State*_____

*Street*_____ *Firm Name*_____

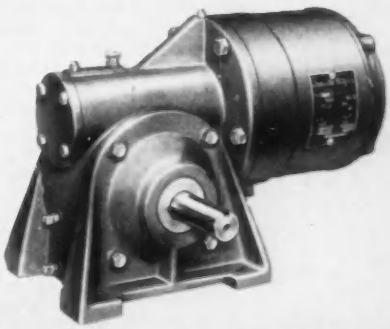
WHERE POWER CONTROL COUNTS MOST...



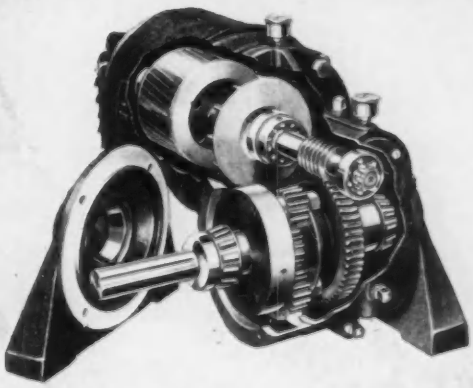
...you'll find Janette

When perfect power control is essential, engineers specify Janette gear motors, speed reducers, and variable speed control drives, because they are integral units—motor and gears are designed for each other—then built by one company to assure perfect reliability, extra long, trouble-free life.

Regardless of the product, Janette has the right speed at the right power for your particular application from 1/150 to 7½ horsepower, in a wide variety of models and in any mounting position. And when your problem demands original research and custom design, you can draw on the nearly 50 years of Janette engineering experience and know-how.



GEAR MOTORS • SPEED REDUCERS



For additional information you are invited

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Janette ELECTRIC MFG. CO.

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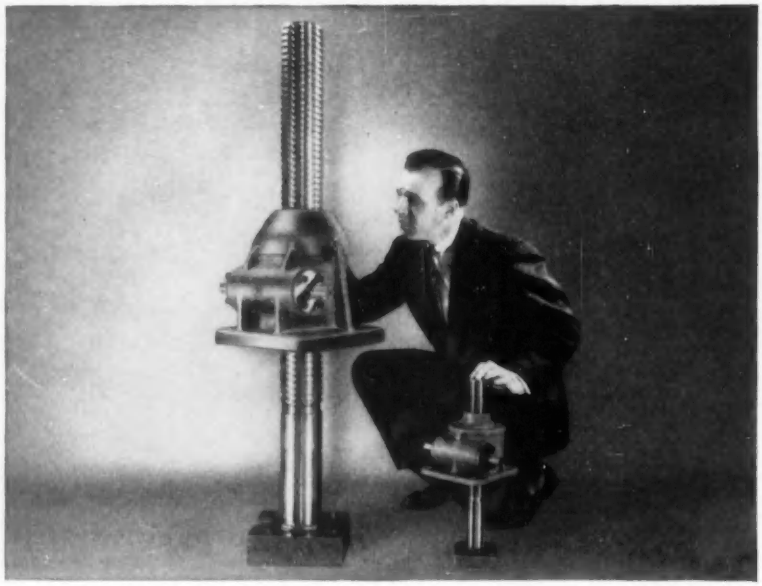


Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 6¾:1 to 32:1; turn of worm for each 1-inch raise, 10 to 48; available in either Acme or square threads. For protection against foreign matter certain models can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—adjusting welding positioners.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes. For complete specifications and detailed drawings, send for your free copy of a special brochure.

DUFF-NORTON Company

DUFF-NORTON COMPANY
Department PE
P.O. Box 1889, Pittsburgh 30, Pa.

Please send immediately a free copy of your new Worm Gear Jack Brochure.

NAME _____ TITLE _____

COMPANY _____ PHONE _____

ADDRESS _____

tion are described. Illustrated with dimensional drawings, contact diagrams and time-delay combinations in tabular form. Atlas Powder Co., Parke Thompson Ordnance Section, 9404 Watson Rd., St. Louis 19.

Circle 73, inside back cover

DRIVE-PIN BLIND RIVETS—Catalog, 16 pp. Contains application data and includes dimensional information, technical details, and grip-range data. Deutsch Fastener Corp., Dept. 36, P. O. Box 61072, Los Angeles 61.

Circle 74, inside back cover

MODULAR ACTUATORS—Catalog 57A, 4 pp. Standard, interchangeable, actuator components are illustrated and described. A master diagram shows the complete line. Also given: a table of maximum operating and ultimate static loads for screw jack; load-speed charts for each screw jack, a selection guide, general engineering data, typical schematic wiring diagram and dimensional information. Airborne Accessories Corp., Hillside 5, N. J.

Circle 75, inside back cover

SPRING PINS—Bulletin, 4 pp. Sizes, materials, finish, hardness, strength, and other specifications are presented in tabular form and drawings. Applications are illustrated. Standard Pressed Steel Co., Box 545, Jenkintown, Penn.

Circle 76, inside back cover

CLAMPS AND FASTENERS—Catalog CF57, 16 pp. Photos, diagrams, descriptions, specifications and ordering information are incorporated. Applications are shown. Specialty Hardware Dept., Bassick Co., Bridgeport 5, Conn.

Circle 77, inside back cover

FLEXIBLE METAL HOSE—Catalog 171, 8 pp. Explains the nature of expansion joints. Gives specification data and characteristics. Flexonics Corp., Maywood, Ill.

Circle 78, inside back cover

POWDER METALLURGY—Bulletin M-2057, 4 pp. Materials and characteristics are discussed and illustrated. Specification data is given in tabular form. Superior Carbon Products, Inc., 9115 George Ave., Cleveland 5.

Circle 79, inside back cover

ONE-PIECE FASTENERS—Bulletin, 4 pp. Principles and advantages of a fastener designed to replace separate screws and washers. Pittsburgh Screw & Bolt Corp., Pittsburgh 30.

Circle 80, inside back cover

WELDED TUBULAR PRODUCTS—Bulletin TB-419, 8 pp. Explains advan-

(Continued on page 163)

tages of resistance-welded mechanical tubing. Supplies information on mechanical properties and lists size tolerances to which the tubing is normally produced. Tubular Products Div., Babcock & Wilcox Co., Beaver Falls, Penn.

Circle 81, inside back cover

CARBON BRUSHES—Booklet GEA-6688, 8 pp. Contains questions and answers covering brush life, metal transfer, commutator threading, bar marking, and commutator adjustment. General Electric Co., Schenectady 5.

Circle 82, inside back cover

STRESS RUPTURE IN TUBING STEELS—Bulletin TDC-153B, 4 pp. Furnishes results of stress rupture tests on 14 steels, including carbon steel, alloy steels, and 10 stainless steels, in temperatures ranging from 850 through 1800 F. Babcock & Wilcox Co., Beaver Falls, Penn.

Circle 83, inside back cover

SPRING WASHERS—Bulletin, 6 pp. Dimensions of standard-size washer dies are listed; also given are available die sizes for making multiple-finger loading springs. Associated Spring Corp., Bristol, Conn.

Circle 84, inside back cover

DIGITAL PULSE DECODER—Manual, 12 pp. Describes the selector and its numerous applications. Illustrated with photos and schematic diagrams. Electrical Communications, Inc., 765 Clementina St., San Francisco 3.

Circle 85, inside back cover

DISCONNECT SWITCHES—Bulletin GEA-6751, 4 pp. Information includes specification form that lists ratings, dimensions and catalog numbers. General Electric Co., Plainville, Conn.

Circle 86, inside back cover

MOLDING TEFLON—Brochure, 4 pp. Covers patented process of custom-molding parts of Teflon in thin sections and shapes. Includes properties and characteristics, and uses, and illustrations of parts. Sparta Mfg. Co., Dover, Ohio.

Circle 87, inside back cover

SHAFT-MOUNTED SPEED REDUCERS—Catalog SM-57, 8 pp. Illustrated booklet discusses weights, dimensions, parts, ratios and ratings, and service and selection factors. Winsmith, Inc., Springville, N. Y.

Circle 88, inside back cover

SELF-LOCKING BOLTS—Catalog, 8 pp. Gives principle of operation, engineering standards, and tightening information. Performance curves, tables, and dimensional

(Continued on page 165)

another high temperature problem solved!

Design engineers, production specialists and men with materials know-how are and will be the heroes of our continued peace.

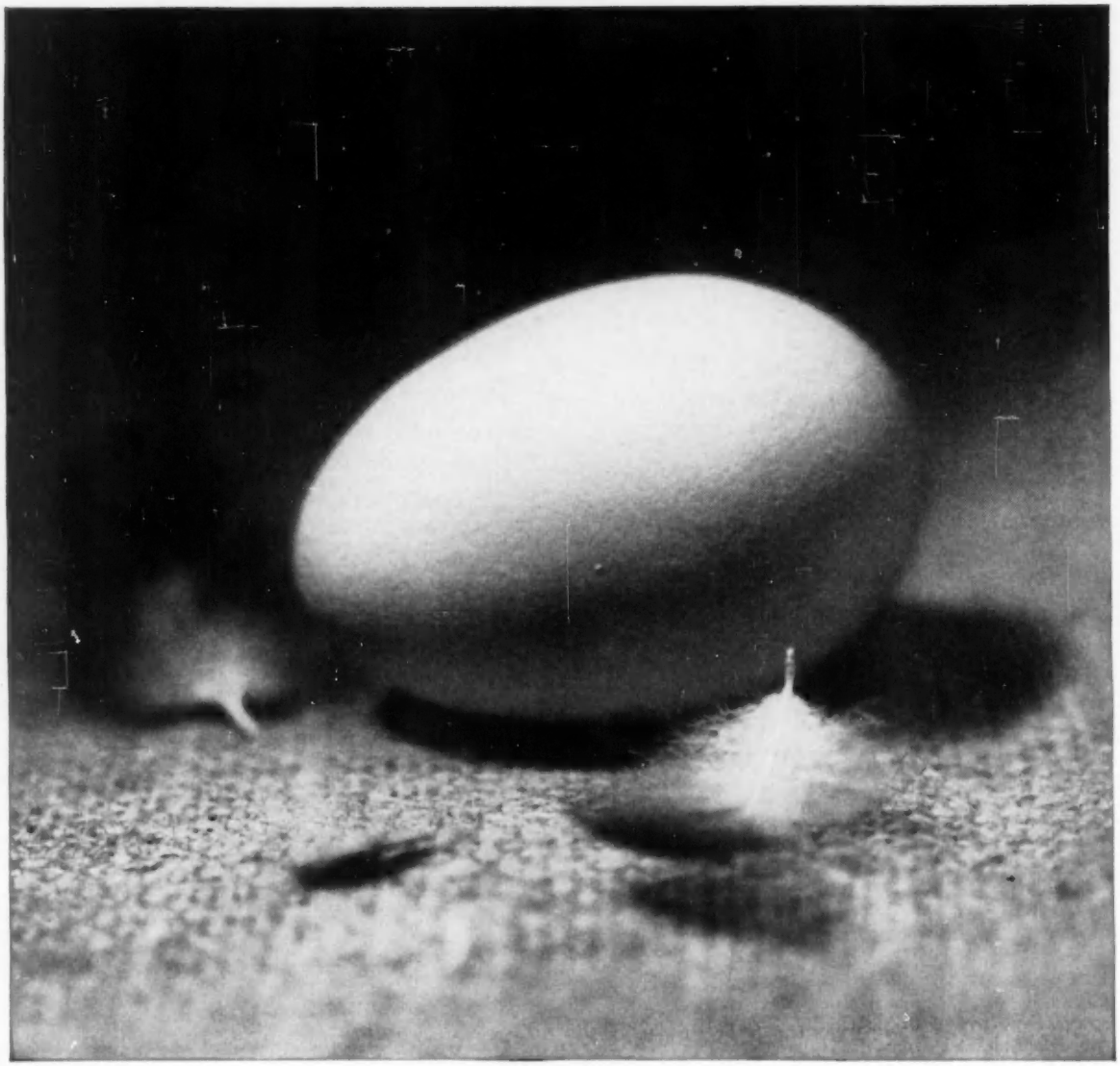
Stalwart is also playing an important role. Silicone rubber parts . . . molded, extruded or die-cut to exacting specifications . . . are solving untold problems where heat and cold are encountered. Silicone parts, capable of withstanding temperatures from as low as —160 F. to more than 500 F. are making drawing board dreams a reality.

If you have a temperature-rubber problem . . . call on The Stalwart Rubber Company, 166 Northfield Road, Bedford, Ohio. Send prints or ask for catalog. Remember . . . your problems may be solved with . . .

STALWART

Silicone

RUBBER PARTS



Masterpiece of simplicity

Consider the egg. Unique in shape, clean of line, its design is functionally perfect.

Much the same can be said of a MAC valve. Trim and compact, its simplified design meets the severe demands of our toughest customer. We engineered it to deliver the speed and stamina required by resistance-welding equipment . . . and knew this basic design would pay off handsomely in performance on less exacting jobs, too. That's why *all* MAC valves are built to these same rugged design specifications.

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Catalogs and Bulletins.....continued

drawings illustrate the booklet. National Machine Products Co., Utica, Mich.

Circle 89, inside back cover

FLEXIBLE SHAFTS—Bulletin 5601, 16 pp. Basic information and specifications on flexible shaft line. Contains descriptions of functions, advantages, nomenclature and characteristics. A table tabulates torque transmitted at different horsepowers and speeds. S. S. White Industrial Div., 10 E. 40th St., New York 16.

Circle 90, inside back cover

CIRCUIT BREAKERS—Bulletin GEAT-6750, 4 pp. Describes industrial line of molded case circuit breakers. Gives enclosure information, ratings, modifications and accessories. General Electric Co., Plainville, Conn.

Circle 91, inside back cover

PURE METALS, MASTER AND FERRO ALLOYS—Booklet, 22 pp. Covers various grades of chromium metal, chromium-molybdenum, ferro alloys, tungsten melting base alloy, zirconium-aluminum, and vanadium-aluminum. Lists experimental alloys available in laboratory and pilot plant quantities. For all of these alloys, chemical analyses and powder mesh sizes are listed. Shieldalloy Corp., Newfield, N. J.

Circle 92, inside back cover

CONICAL KEYSTONE LOCK BLIND RIVET—Catalog, 16 pp. Line drawings show the step-by-step driving cycle. Complete dimensional data and specifications. Driving procedure is discussed and illustrated. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich.

Circle 93, inside back cover

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MODERN ELECTRONIC ENGINEERING GIVES PRECISE MOTOR SPEED CONTROL

1/100 — 10 H. P.

Modern industrial electronic engineering has been coordinated with electric motor design to provide a versatile means for obtaining the full possible advantage of speed control in DC motors while operated from the regular alternating current power line. Grid controlled "Thyratron" tubes are utilized for power controlled stepless variation to supply motor armature power. Patented feedback, or "Servo" circuits provide constant torque capability over wide speed ranges of as high as 60 to 1 in some models and a minimum of 20 to 1 in others.

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Metallic.....Organic.....Decorative.....Protective

New type chromium plate improves products

Why Crack-Free Chromium gives superior finish

Regular chromium plate develops a network of cracks as it is deposited. Through these defects, corrosives reach the underlying metal. Deposits from the Unichrome Crack-Free Chromium Plating Process remain structurally sound and continuous. This explains the wide difference in degree of corrosion protection obtained.

OTHER PROPERTIES

Crack-Free Chromium also provides:

1. Increased ductility, so that expansion and contraction cause no cracks.
2. Improved non-galling, non-seizing properties.
3. Low friction, resistance to wear.
4. Hardness (500 to 700 Knoop).
5. Excellent leveling action to help cover surface irregularities and reduce grinding needs.
6. Protection to the base metal without undercoats.
7. A satin matte *decorative* finish that can be applied directly to zinc die casting as well as steel. It buffs readily to high luster.

Bulletin CFC-2 gives more details on self-regulation and other features.

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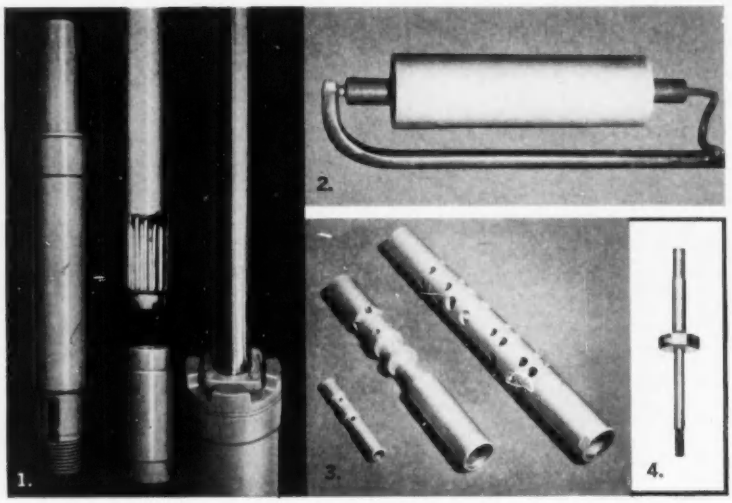

Difficult problems created by heat, wear, corrosion solved by Crack-Free Chromium

Field reports confirm that Unichrome Crack-Free Chromium is truly a new type of chromium plate with valuable characteristics. It is being used in applications once thought impractical for chromium or other deposits.

IMPROVING HYDRAULIC SYSTEMS

On hydraulic rams, power steering shafts, hydraulic jacks being plated with Crack-Free Chromium, relatively thin deposits protect against corrosion, reduce friction and wear. Where aqueous hydraulic fluid penetrated the cracks in .003 to .005" of ordinary chromium, a .0009" Crack-Free deposit stopped it.

Washing machine and typewriter parts, spline shafts, piston rings, relay armatures are other applications where corrosion problems have been solved.

COMBATING THERMAL SHOCK

Spouts for pouring 2250°F. molten glass into molds last four times longer when plated with Crack-Free Chromium instead of ordinary chromium. Molds for TV tubes, subject to corrosion at the cracks in ordinary chromium, now last 5 to 10 times longer.

Increased ductility combines with resistance to thermal shock for other benefits. Faster, deeper grinding cuts can be made on this new chromium without fracture. On renewed transmission cams, this plate didn't fracture in service, whereas ordinary chromium did on 30% to 40% of the cams.

SLOWING DOWN WEAR

Crack-Free Chromium enables one user to increase life of textile machine rolls by 400% while cutting chromium deposit thickness 95%. It has also increased service life of drills, taps and reamers by 300%, compared with ordinary chromium.

Send for Bulletin CFC-2.

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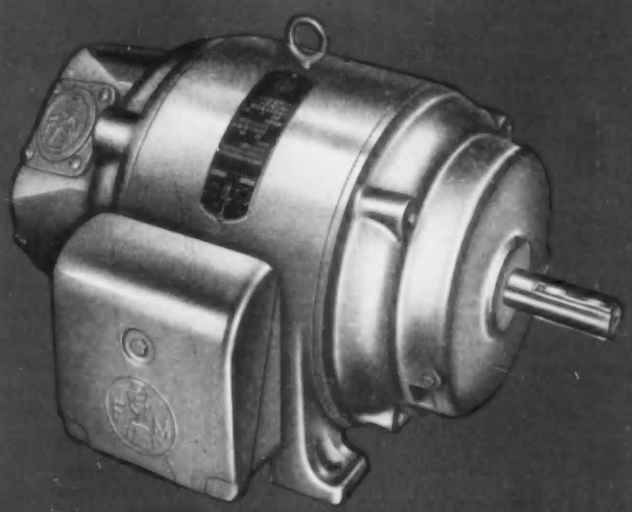
Newest addition to the F-M line of improved electrical equipment, single-phase capacitor-start motors are designed for severe applications.

New drip-proof frame and bearing arms are rigid, durable, corrosion-resistant. No pressed steel or sheet aluminum in any structural part. Famous F-M Copperspun rotor with shaft, fans and centrifugal switching mechanism dynamically balanced as a unit for smooth, vibrationless operation.

Starting capacitors are designed for maximum starting torque . . . minimum starting current. Rugged, trouble-free centrifugal switch features oversized snap-action contacts.

New Bulletin 2401 giving complete details will bring you up to date on the newest in capacitor-start, induction-run motors. Write: Fairbanks, Morse & Co., Dept. PE-1028, Chicago 5, Illinois.



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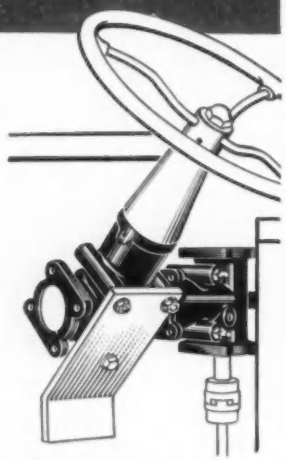
ANGLgear® solves steering linkage problem



Simplified drawing based on photo shows ANGLgears used as steering linkage on John Morrell Co. Mor-Lift fork truck. ANGLgears adapt easily to different steering column angles of various Mor-Lift models.

In designing steering linkage for its Mor-Lift fork trucks, John Morrell Mfg. Co., Elgin, Ill., faced a problem of transmitting rotary motion through two 90° angles. Costwise, standard bevel-gear units were indicated. However, Morrell engineers also needed the design flexibility of custom gearing because of the different steering column angles of various Mor-Lift models.

Two standard 5 hp ANGLgears finally solved the problem. Their compactness and 4-way mounting feature made them easily adaptable to any steering column angle. This eliminated the cost of custom gearing and saved engineering time and expense.

Perhaps ANGLgear can solve a 90° drive problem for you. Designed for manual or power operation, ANGLgears come in ⅓ to 5 hp sizes, with 2- or 3-way shafting and 1:1 or 2:1 gearing.

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DESIGN ABSTRACTS

Papers from Wescon Convention Aug. 20, San Francisco

Evaluating Engineers and Scientists

Twenty-seven variables—such as class standing, age, level of engineering degree, number of dependents—are analyzed statistically, and a predicting equation is developed. This equation is said to determine entrance salary within 6% accuracy. Some of the variables, generally assumed to be important, are shown to be statistically insignificant.

Abstracted from "Evaluating Engineers and Scientists for a Research and Development Activity," by R. A. Martin and James Pachares, Hughes Research and Development Laboratories.

Systems Engineering

This proposed step-by-step process for solving systems-engineering problems includes statement of problem, criteria for judgment, synthesis, analysis, implementation. The technique is reported to operate like a feedback network, and may be used both in R & D and product design.

Abstracted from "Systems Engineering," by I. L. Auerbach, Burroughs Corp.

Welding Design for Improved Vibration Control

Control of vibration is a design problem in machinery of many different types. In the past, this problem, to some extent, has discouraged designers in the use of weldments. It has been felt that the damping capacity of cast iron is an advantage in controlling vibration. Contrary to popular belief, efficiently designed welded steel has superior properties for coping with vibration problems found in many types of machine tools.

In recent years, there has been considerable research among machinery builders on the subject of vibration.

Efficient steel weldments weigh less than corresponding castings and this reduced weight will not create vibration problems. On the contrary, steel has superior properties for designing where vibration is an important consideration. Steel can have a damping capacity equal to or greater than cast iron because an equivalent steel design under the same load takes higher stresses. The reduced section of the equivalent steel design has a greater modulus of elasticity; hence, reduced amplitude of vibration and, therefore, higher natural frequency. This means a greater operating range. The design flexibility of welded steel makes it easy to shorten unsupported lengths and make other changes that decrease amplitude.

Abstracted from "A New Concept of Welded Design For Improved Vibration Control," by Omer Blodgett, *The Welding Journal*, Aug. '57.

Bonding of Semiconductors and Leads

Thermocompression bonding is a process that combines heat and pressure to provide a bond between various soft metals and semiconductor surfaces. Resulting bond is reported to be stronger than the lead material itself. Temperatures and pressures required are not high enough to affect electrical properties of the semiconductor material. Two techniques are described, both readily adaptable to mass production and requiring no flux. The process is presently being applied on a laboratory basis.

Abstracted from "Thermo-compression Bonding," Bell Laboratories Record, Sept. '57.

When to Take Time for Machinery Replacement

This paper analyzes the effect of recurrent replacement on the expected time-to-failure of individual componets or groups of components. Recurrent replacements will be of two types: strictly periodic replacement and random replacement. The latter type is most applicable in aircraft servicing where parts cannot be replaced in midflight or, in general, whenever the work cycle of a given device is variable and the device cannot be replaced in midcycle.

A particular question discussed: Is it always better to have a policy of finite replacement than to replace only upon failure? It is concluded that a careful scrutiny of the relia-

(Continued on page 171)

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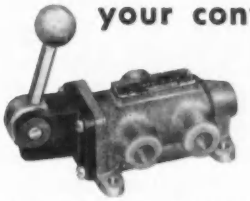
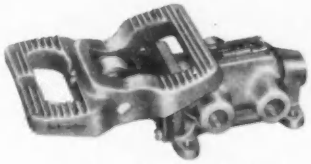
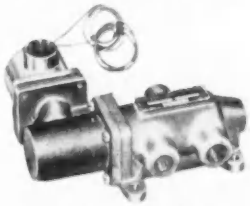


Hand-Operated Four-Way Valve



Foot-Operated Four-Way Valve

Pilot-Operated Valve



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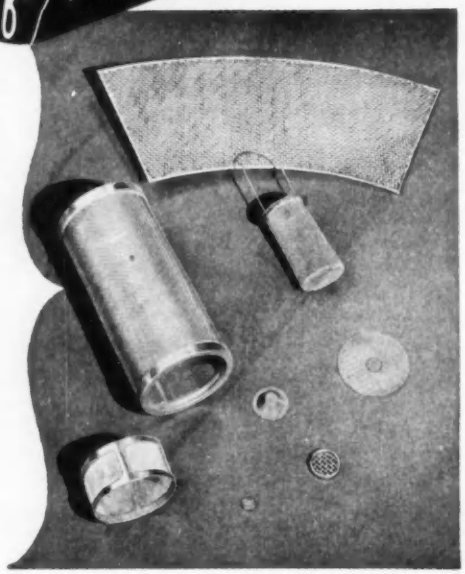

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bility function is necessary before any replacement policy is decided upon. A partial criterion for decision is given.

Abstracted from Ballistic Research Laboratories, Memorandum Report No. 982, "On the Theory of Replacement of Machinery with Random Failure Time," by Pfc. G. H. Weiss/ orc, Aberdeen Proving Ground, Maryland, Mar., '56.

Papers from Fall ASME Meeting, Hartford, Conn.

Why Safety Engineering in Design

Designing safety into machinery and equipment does not end with application of known data on strength of materials, stress analysis and following accepted codes and standards. Need for consulting with safety engineering staff on all phases of design—and not only after an accident or other crisis occurs—is indicated and the role of such specialists is defined.

Abstracted from ASME paper No. 57-E-35, by J. W. Grimaldi, General Electric Co.

The What of Safe Design

A definition of hazards in day-to-day machine operation is presented, together with listing of types of hazards. Principles of safe design are then discussed. An analysis of the various means of providing monitoring or feedback of information required to warn of potentially dangerous machine conditions is also included.

Abstracted from ASME paper No. 57-F-32, by N. Prasinos, *Modern Materials Handling.*

Standardized Notation and Classification for Four-bar Linkages

The system of classification developed is intended to help a novice perceive the characteristics of a four-bar linkage at a glance. The notation proposed is for writing general equations. Several other aspects of four-bar linkage are standardized. The entire system has a mathematical basis but, in most cases, can be applied by visual examination of a given linkage. The system is proposed for adoption as a standard.

Abstracted from ASME paper No. 57-F-28, by B. L. Harding, Heald Machine Co.

Project Control in Engineering Development

Based on the author's work as a consultant, this paper describes a planning and scheduling system de-

(Continued on page 173)

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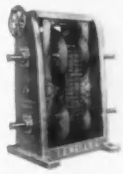
Horizontal Enclosed V/S Transmission

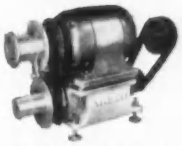

Vertical Open V/S Transmission

Vertical Enclosed V/S Transmission

Variable Pulley

Variable Pulley with Counter Shaft

Combination Pulleys


Combination Pulleys with Counter Shaft

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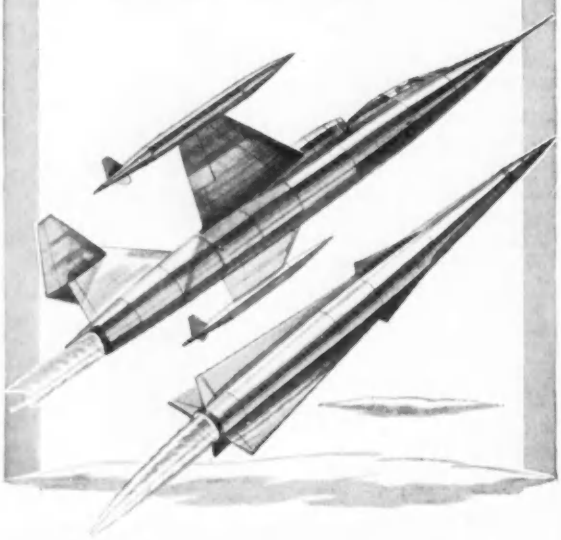

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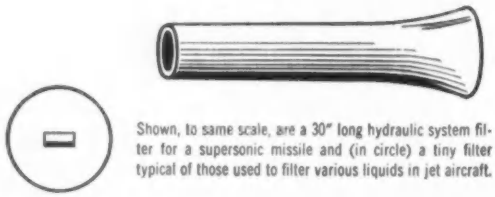

Shown, to same scale, are a 30" long hydraulic system filter for a supersonic missile and (in circle) a tiny filter typical of those used to filter various liquids in jet aircraft.

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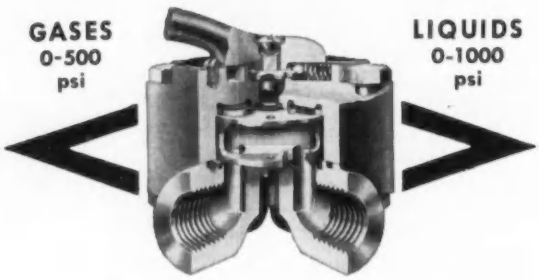

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veloped for the operation of a propulsion wind tunnel. The plan of work adopted helps project engineering groups involved, supplies information required for managerial control and direction, and improves and increases utilization of the tunnel.

Abstracted from ASME paper No. 57-F-2, by G. L. Thuering, Pennsylvania State Univ.

Organize Your Engineering Project

A system of recording for use-information developed in product planning, cost studies, calculations and other engineering processes is proposed, based on a card-filing system similar to that in public libraries. The system is described as applied to a $3.5 million power project.

Abstracted from ASME paper No. 57-F-11, by M. Tourtellotte, Michigan Seamless Tube Co.

Conductive and Resistive Coatings

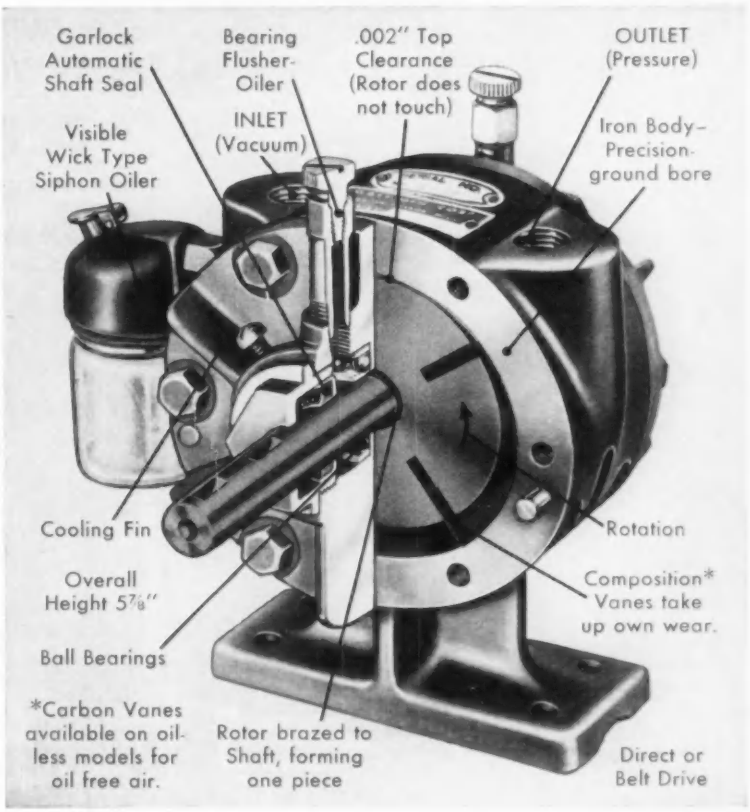
Resins and lacquers pigmented with metals or carbon can be applied like paint to give thin over-all films, provide complex patterns or cover irregular surfaces. Present applications, besides conducting current or generating heat, include use as electrical shields on electron tubes, radar housings, encapsulated components. Conductive coatings have been used as resistor terminations, printed-wiring circuits, flexible waveguides. Selection of proper vehicle for the conductive material, applications technique and equipment, drying procedures, other significant coating characteristics are discussed.

Abstracted from "Conductive and Resistive Coatings," by R. J. Phair, Bell Laboratories Record, Sept. '57.

Influence of Pinch Fits on Fatigue

This is a thesis for a doctorate in engineering published in W. Germany, which describes the results of tests on various materials to determine the influence of pinch fits on alternating torsional fatigue limits. Test equipment and procedure are described. Indications of losses in endurance as high as 43% are reported.

Abstracted from "Alternating Torsional Stress Fatigue Limit of Shafts and Influence of Pinch Fits," by E. A. Cornelius, Konstruktion, Sept. '57, No. 8.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rotary vane

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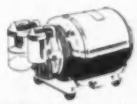
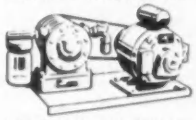
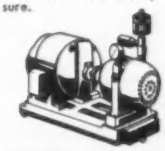


INTEGRAL-MOTOR PUMPS 1/12 to 1/3 H.P. .6 to 4 CFM. to 28" VAC., to 25 PSI.



LIGHT-DUTY PUMPS, V-belt or direct drive. 2 to 24 CFM. Moderate vacuum or pressure.



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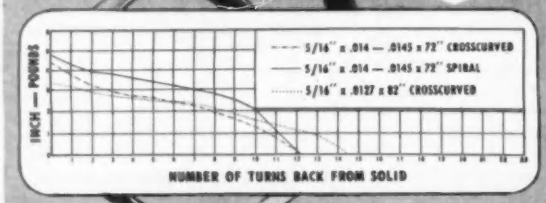
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5/16" x .014 — .0145 x 72" SPIRAL
5/16" x .0127 x 82" CROSSCURVED
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Section showing crosscurved spring in housing.

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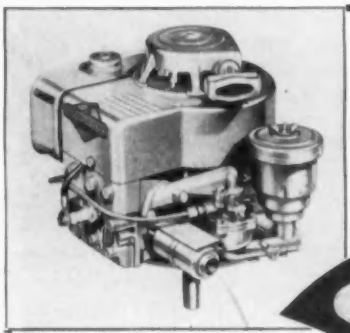

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Technical Descriptive Geometry

B. Leighton, *Professor of Mechanical Engineering, Worcester Polytechnic Institute*, 9¼ x 6¼ in., 627 pp. Published by McGraw-Hill Book Co., Inc., 330 W. 42 St., New York 36, N. Y. $5.75.

A comprehensive and modern treatment of the theory and practical application of descriptive geometry. The entire subject is developed realistically from a natural, logical viewpoint. Consistent with industrial practice, attention is concentrated on the object itself, and the direction of sight for the various views is emphasized.

An improved presentation of visibility, perpendicular lines, views of a circle, and cylinder intersections is included in this second edition. A complete analysis of many important problem is given with a concise summary of key ideas.

Transistor Circuits and Applications

Edited by John M. Carroll, *Associate Editor, Electronics*, 8½ x 11 *in.*, 285 *pp. Published by McGraw-Hill Book Co.*, 327 W. 41st St., New York 36, N. Y. $7.50.

Detailed information on how to apply transistors in military, industrial, and home-entertainment equipment is offered in this book, which is based on articles that appeared in *Electronics* magazine. It covers typical transistor operating characteristics, important circuit parameters, transistor types, problems of temperature and gain stabilization, and includes a large number of typical transistor circuits.

These circuits show component values and include portable and automobile radios, audio amplifiers, military communications equipment, telemeters, servo amplifiers, computers, industrial and medical instruments, and hearing aids.

The book covers *h* and r design parameters, new transistor structures such as silicon units, power transistors,

(Continued on page 177)

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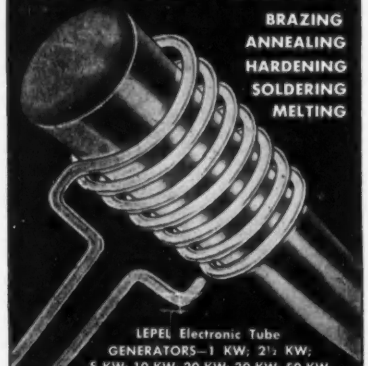

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tetrodes and diffused junction units. It shows circuits using silicon and high-frequency transistors. Direct-coupled computer circuits and complementary-symmetry circuits are also included.

Operating characteristics of over 200 commercially available transistors are listed.

Induction-motor Torques Defined

Abstracted from Induction Motor Torques Defined, by R. C. Moore, Motor and Generator Dept., Allis-Chalmers Mfg. Co. Allis-Chalmers Electrical Review, 2nd Quarter, 1957.

The specific relationship between the various types of induction-motor torque curves and load torques has seldom been clearly or extensively defined. This article describes such types as friction torque, motor-windage torque and motor damping torques. Although there are many types of motor torques found in motor theory and design, only the few important types met in specifications or applications are covered here.

Examples and illustrations of matching motor torque to load torque are given for several representative examples, supported with graphs and charts. Standard torque terms are also defined in considerable detail.

A Bibliography of Fluid Power

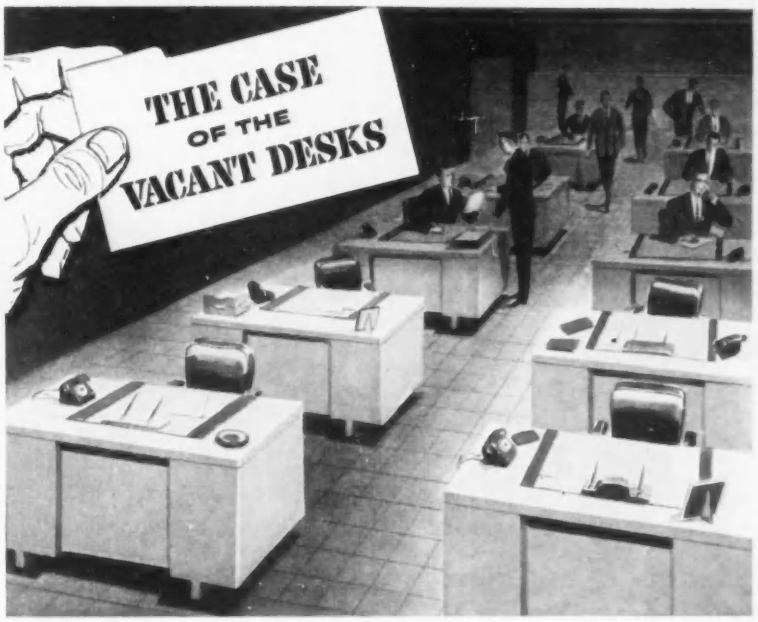
Prepared by National Fluid Power Association, 1618 Orrington Ave., Evanston, Ill. 9 x 11½ in. $2.

This is the first reasonably complete bibliography devoted solely to fluid power. As such, it is a welcome and valuable reference for the experienced fluid power designer as well as the novice searching for the best texts in the field.

Some 70 volumes are listed, each on a separate sheet, giving author, publisher, date, price, number of pages, number of illustrations, an abstract of the forward or introduction, and the table of contents. The bibliography is loose-leaf-bound so that additions may be inserted.

Listed books are divided into hydraulics, pneumatics and fluid power

(Continued on page 179)



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as major categories and further subdivided into applied, basic theory, control, data tables, advanced theory and general.

Although only books are included here, the NFPA hopes to publish a similar bibliography of articles and papers. Anyone interested is requested to send to the headquarters office lists of papers and books annotated with the necessary publishing history.

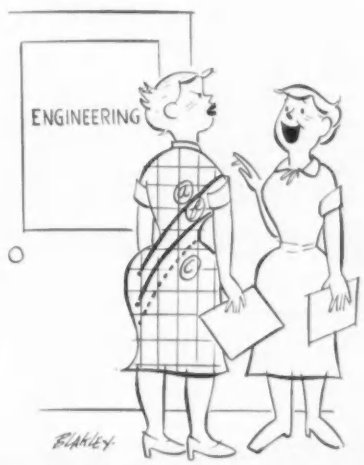
Standard Handbook for Electrical Engineers

Edited by ARCHER E. KNOWLTON, *Consulting Editor, Electrical World, 6½ x 9¼ in., 2311 pp. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y. $19.50.*

This reference guide to the electrical industry is a considerably revised and modernized edition of an established work. It incorporates important facts and data on developments in meterials, methods and applications that have taken place during the eight years since the last edition. More than 100 engineers, scientists and other authorities have contributed to produce an encyclopedia of facts and figures, definitions, conversion factors, physical and mathematical principles, accepted formulas and experimental data, in compact form.

Among the subjects covered are communication (wire and radio),

(Continued on page 181)



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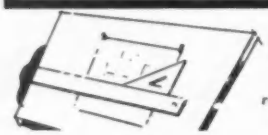

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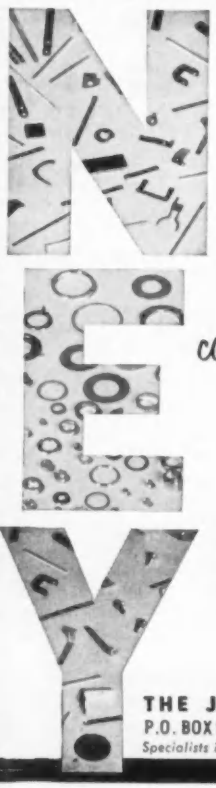

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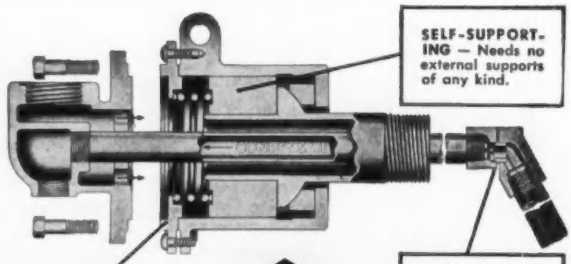
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Investment Casting

Paperbound, 8½ x 11 in., 50 pp. Published by Investment Casting Institute, 27 Monroe St., Chicago 3, Ill. $5.

This first engineering and design manual to be published by the Institute represents the general level of the art. The valuable design section assembles information previously dispersed in a number of articles and individual company publications.

Because it represents the common level of the industry, this section makes possible part design that can be produced by any investment casting organization. Specifications cover the cast tensile test bar, which is now standardized throughout the industry, and the more common alloys.

Science of Engineering Materials

J. E. Goldman, *Editor.* 6 x 9¼ *in., 520 pp. Published by John Wiley and Sons, Inc., 440 Fourth Ave., New York 16, N.Y. $12.*

This book is the outgrowth of the Carnegie Conference on the Impact of Solid-State Science on Engineering Education held at the Carnegie Institute of Technology in June, 1954. Both conference and book are an attempt of physicists concerned with engineering education to give the en-

(Continued on page 183)

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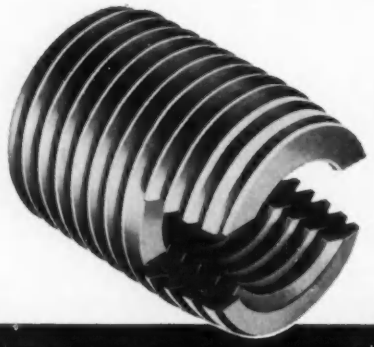

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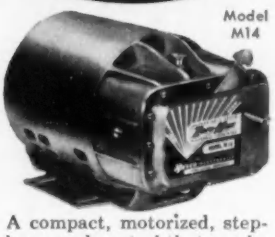

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gineer a basic approach to the understanding of solid-state science.

The six sections of the book: The Structure of Matter, Metals and Alloys, Surfaces, Magnetism and Magnetic Properties, Semiconductors and Dielectrics, and Non-Crystalline Materials, contain a total of 18 papers by specialists in the subject fields.

Early chapters provide the necessary background in modern physics and offer an analysis of the general scope and terminology of the solid state.

Designing for Production

EDWARD N. BALDWIN, *Manufacturing Consultant, Westinghouse Electric Corp., and Benjamin W. Niebel, Chairman, Industrial Engineering Dept., Pennsylvania State University. 6 x 9 in., 645 pp. Published by Richard D. Irwin, Inc., Homewood, Ill.* $8.40.

The major engineering materials, including ferrous, non-ferrous, plastics, rubber and synthetic rubber, are described from the product designer's viewpoint. Information is presented to enable the designer to select the material best suited to his design with function, processing, service life and cost taken into consideration.

In addition, the principal manufacturing processes, including metal forming and shaping, metal cutting, joining and finishing processes and packaging are presented to enable the designer to develop a product that is functionally sound, marketable and profitable.

"Would you care to scowl at some more of my work, sir?"

LOW NOISE LEVEL BRUSHES BY SUPERIOR

More and more, Industry is calling upon a Superior willingness to study a specific situation and come up with an answer that will make possible optimum brush performance.
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More and more, a specialized Superior 37-year background is finding satisfactory solutions to these problems.
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SCP SUPERIOR CARBON BRUSHES "Since 1919"

Designed by Experience

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600 Volts A-C or D-C

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If you buy or specify forgings, write for this fact-packed AmForge book. Its 16 pages show how your company can benefit from better AmForge research, engineering and control. You'll see that all this adds up to the kind of "service" you need for production quality and economy. Either circle the number on the magazine service card or write AmForge, Dept. PE10, 157 N. Wacker Dr., Chicago 9, Illinois.

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CHAGRIN FALLS, OHIO

OUR READERS SAY . . . . . .

Letters should be addressed to the Editor, *Product Engineering*, 330 W. 42 St., New York 36, N. Y.

Train Stamp

To The Editor:

The August issue of *Product Engineering* was recently routed to my desk. Unfortunately, after passing through quite a few hands, the cover was badly torn. You may wonder at my interest in the cover but when I say that I am not only a product engineer but a railway mechanical engineer, a model-railway enthusiast and a collector of railway miscellany on stamps, perhaps you can understand.

I have heard that the Peruvian government is planning a new commemorative stamp that may include a view of the Alco DL-500 shown on your cover.

This commemorative stamp is purely a rumor in philatelic circles at the moment. However, over the past 10 years most South American countries have honored their roads with stamps commemorating their inception, electrification, and certain historic locomotives. Such a stamp from Peru is lacking. The road you have pictured on your cover probably has the most

(Continued on page 187)

"Their best ideas come to them asleep, in the tub or while shaving, you see."

FOR A BETTER COOLANT SYSTEM

TYPE 6-P3

Specify RUTHMAN GUSHER Coolant Pumps

Illustrated is a Model A-20-2-HC Test Unit manufactured by Cincinnati Sub Zero Products and equipped with a Model TL-7320 Gusher Pump.

Your coolant worries are over when you use a Gusher Pump on your coolant system. A Gusher not only gives efficient split-second coolant delivery, but it is pre-lubricated, needs no packing, foot or relief valves. You get longer pump life with minimum attention. Send for Catalog today.

Write today for catalog

THE Ruthman MACHINERY CO.

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- COOLANT PUMPS
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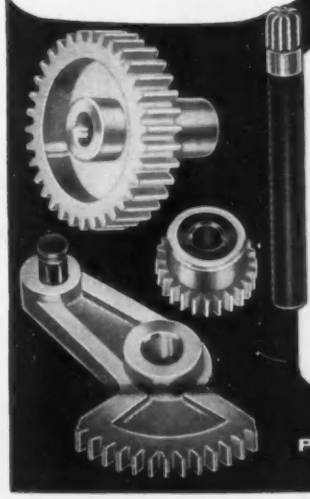
NOW! new economies in NYLON GEARS means savings in gear costs up to 90%



Our many years of successful production of Nylon Gears can now make even greater economies for you. With the great variety in molds now possible, Nylon should not only be considered as an economy measure but the answer to many problems where compact design is necessary. Nylon Gears are quiet, durable, efficient and need less lubrication—they mate perfectly with metal gears.

Let our engineers with more than a decade in gear experience consider your gear problems DURING the design process—send blueprints or specs for prompt estimates.

Gears made only to your specifications. None carried in stock.

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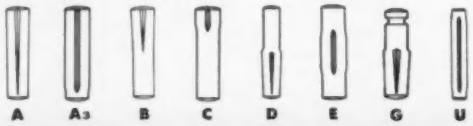
complete details on grooved pins and studs

Your copy of the new DRIV-LOK grooved fastener catalog is ready now. Write for it today. 24 pages of factual data in concise, easy to use form. No obligation, of course.

STANDARD TYPES . . . A COMPLETE LINE



DRIV-LOK PIN COMPANY

723 Chauncey St. • Sycamore, Illinois

interesting history of all, and being one of the biggest railroads in the world, surely demands some philatelic recognition. The picture and your fine editorial would assist in making an excellent writeup for this stamp.

—J. M. PRENDERGAST, JR.
Western Electric Co., Inc.

Weight Computations Simplified

To The Editor:

Don't laugh, but constantly having to make weight computations, I sought a simplification of the volume formula for hollow cylinders. The solution I came up with uses a slide rule and goes something like this:

$V = (D^2 - d^2)\ \pi h/4$. Calling $d/D = M$, we have $V = D^2\ (1 - M^2)\ \pi h/4$. Now $(1 - M^2)$ is easily computed by calculating d/D on the C and D scale of the rule. This gives M^2 on the A scale. $(1 - M^2)$ can be obtained by counting back from A100 or A10. Using A100, you directly obtain 0; using A10 you obtain 0.9 plus the quantity counted backwards. For example, if $M = 0.42$, $M^2 = 0.176$ Counting from A100 you will get 824, which is $0.824 = (1 - M^2)$. This gives you all the necessary factors.

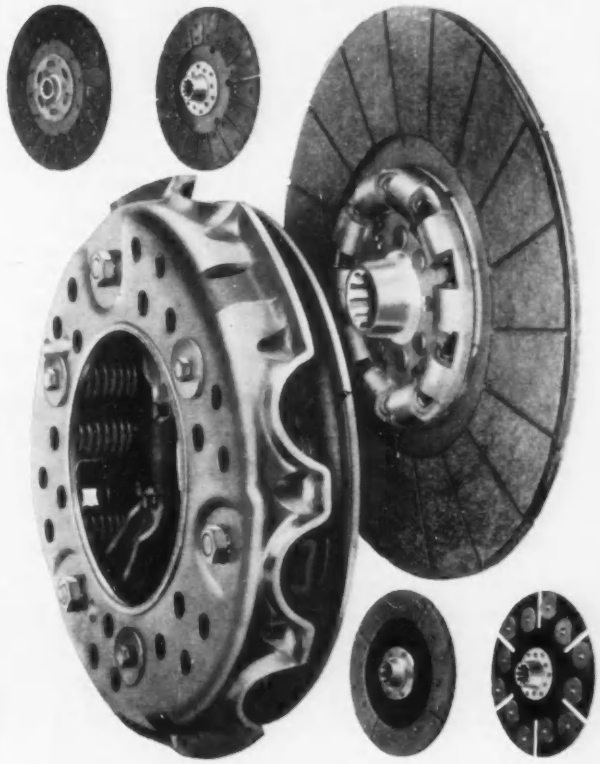
The European slide rules are better suited for this than some of the modern American rules, which lack the $\pi/4$. Best of all is the Darnstadt rule with a P scale that gives the values of $\sqrt{1 - X^2}$ for the x on the D scale.

—CARLOS JANSKY
Tigre, Argentina

"At twice the speed of sound, she seems to lose most of her pickup."

ROCKFORD

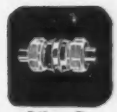
A Clutch Plate - for Every Use



Small Spring Loaded

Automotive Spring Loaded

Heavy Duty Spring Loaded


Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

ROCKFORD CLUTCHES are made with a wide variety of friction plates—to meet your specific needs exactly. Organic, metallic, segment or Morlife® cerametalic facings provide the right torque, wear and heat resistance characteristics. Cushioning arrangements minimize the effects of shock-load engagements. Dampeners blot out vibration and chatter. Pressure plates of high tensile strength resist centrifugal force of modern high speed engines. These ROCKFORD advantages will help you select the *right* friction clutch for your particular needs.

SEND FOR THIS HANDY BULLETIN

Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER

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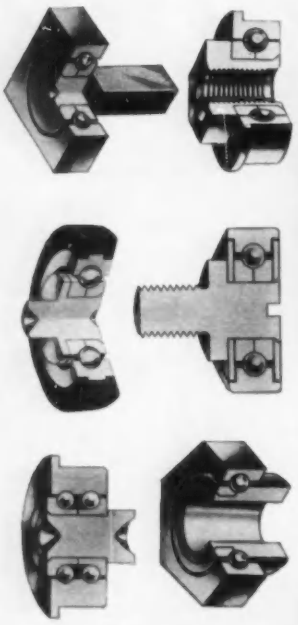
ENGINEERING B-W PRODUCTION

CLUTCHES



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Long life and service are assured you because —

1. All component parts are machined from steel bars.
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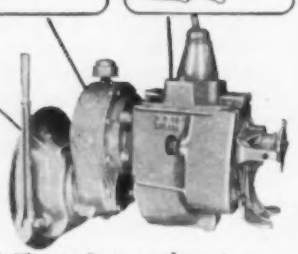
FUNK MODULAR POWER UNITS



Eliminates expensive tooling and special castings . . . simplifies designing and production . . . FUNK'S Standard Flange System does the trick!

Because all FUNK MODULAR POWER UNITS have a Standard Flange System, there is no limit to the number and arrangements that can be assembled without special engineering. These precision made units insure long life and trouble-free service. Our engineers will be happy to solve your specific power transmission problems.

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The Precision Light for Precision Seeing

Provision for fast, accurate operator "seeing" efficiency is vital in machine tool design. Fostoria Localites provide instantly controlled, high intensity precision lighting of the work area zone. Frictional arm and collar disc joints give flexibility of a thousand positions to direct light exactly as needed. Ruggedly constructed with heavy duty industrial socket, Levolier switch and SPT-2 18/2 rip cord wiring. Reflector types and arm lengths to suit any application. Request full information.

Available in many standard models or specially designed in production quantities.

WRITE for complete catalog of Localite Models for every industrial use.

THE FOSTORIA PRESSED STEEL CORPORATION, FOSTORIA, OHIO
Localites are available through wholesalers everywhere

LOCALITE fostoria for Light ON the Job

PRESS PREVIEWS

Nuclear Plant Opens in Canada

Canada's atomic-energy-for-peace program took a step forward when the first fuel rod was completed and operations began at the new Port Hope, Ont., plant and nuclear laboratory of AMF Atomics (Canada) Ltd., a subsidiary of American Machine & Foundry Co. This is Canada's first privately owned setup of the kind organized for nuclear research, development, engineering and manufacturing. The 36,000-sq-ft facility is expected to develop into a large nuclear center.

Formica Expands Production

A 30% increase in production facilities at its Evendale, Ohio plant is expected by the Formica Corp. subsidiary of American Cyanamid to result from construction now underway. Floor space is being increased to more than 550,000 sq ft.

Production of laminated plastic will be stepped up by adding a new press and two new treating machines following completion of the building, in the spring of 1958.

Daystrom Coins "Latest Word" in Process Control

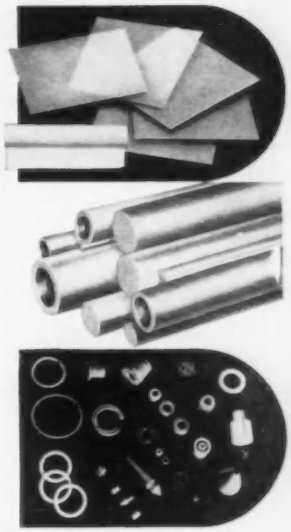
Daystrom Controlonics Group has been formed to provide industry with complete electronic systems for instrumentation and automatic control of industrial processes. This follows the recently announced organization of the Daystrom Avionics Group, which specializes in providing systems

(Continued on page 191)

START WITH THE BEST!

Are you up to date
on Fluorocarbon Stock and Parts?

SHAMBAN TEFLON*
KEL-F, CALIFILM
Tape • Sheet • Rod • Tubing •
Custom Molded or Machined Parts



Exacting specifications? Meet or exceed 'em with SHAMBAN! Whatever your requirements in Teflon, Kel-F and Fluorothene—SHAMBAN *can supply them!*

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Throughout industry, SHAMBAN's remarkable Qualities are pointing ways to *improve* existing products—providing opportunities to create *new* products and applications! Write, wire or phone for complete data on how SHAMBAN can help you.

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Use the BEST in Fluorocarbon Products, Specify SHAMBAN!

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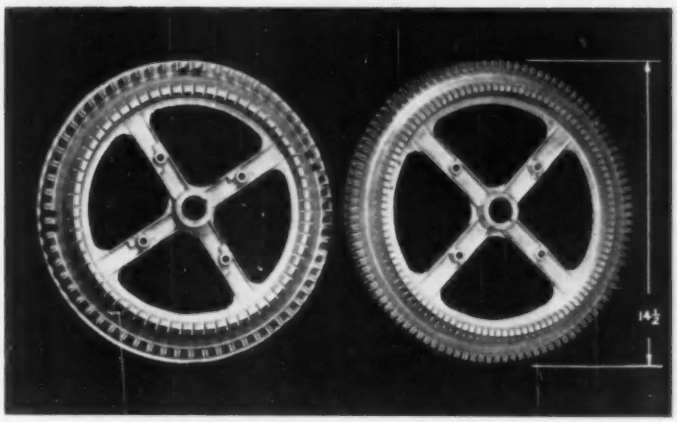

Feasible with "IMPACT INJECTION" of aluminum. The old model 128 slots, the new 216 slots. Each slot is .060 wide by .375 deep. You gain confidence thru our experience

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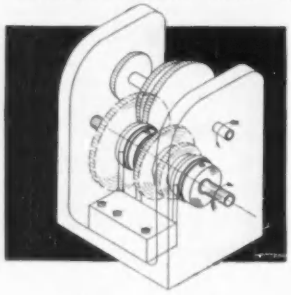
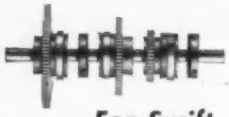
Simplatrol

MINIATURE AND SMALL ELECTRIC CLUTCHES & BRAKES



3-speed transmission
Composed of gears actuated by miniature Simplatrol Clutches.



. . . For Swift, Silent Automatic Speed Selection

Electric Speed Selection is a key function in automated operation, and Simplatrol Electric Clutches and Brakes are providing extremely swift, silent, economical speed selection in varied installations in instrumentation.

PRECISION MANUFACTURED

Simplatrol miniature and small electric clutches and brakes are precision made to close tolerances. There are no sliding parts to wear. The patented diaphragm is the only moving part in the actuation of the clutch and brake. Design is simplicity itself, operation is trouble free.

Ask for recommendations on Simplatrol units for your clutching, braking or speed selection operations.

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Representation in Key Industrial Areas

BREATHER-FILTER

protects housings, crankcases, storage tanks.

The Air-Maze breather-filter keeps dust out of engine and compressor crankcases, gear-cases, hydraulic equipment, liquid storage tanks and machinery. Types and sizes available in both oil-wetted and oil bath models to protect every vented housing.

In the oil-wetted type, dust is impinged on a series of oil-wetted wire baffles. In the oil bath type, used where the dust concentration is unusually high, the filter media is enclosed in a bowl. Outside air must first pass through the oil, then the filter media, before entering crankcase or housing. Also functions as a backfire flame arrester.

Available in sizes from ⅛" to 3½". Permanent, all-metal, easily cleanable. Write for booklet BC-453. Made by AIR-MAZE CORPORATION, Cleveland 28, Ohio.

WHEELS WHEELS WHEELS for Products That Roll!

Be SURE With —

ALLIED Rubber Tired, Metal Disc Wheels; All Sizes & Kinds!

CONSULT ALLIED ON ALL YOUR SMALL WHEEL NEEDS!

• Build quality—lasting service—sales appeal — customer satisfaction into your product with ALLIED Wheels! Big range of stock sizes and types — or produced to your precise specifications. Priced "right"; with dependable delivery to meet your production schedules

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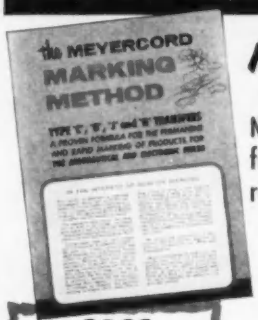
MEYERCORD LICKS TOUGHEST PRODUCT MARKING PROBLEMS!



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MEYERCORD MARKING METHOD
We've just published new data about Meyercord Types C, G, J, & H (heat resistant) nameplate markings, designed to meet the challenge of the most difficult surfaces. For your free copy, please write on company letterhead.

***New* MEYERCORD**
TYPES C, G, J, and H.
Name plate markings designed for heat, abrasion, weather resistance and new finishes

Heat . . . abrasion . . . weather and many of the new surfaces are deadly enemies of most types of product markings. But not to the new improved Meyercord Markings, Types C, G, J and H (heat resistant). Depending upon the surface and the conditions of use one of these new-type Meyercord Markings will, by actual test, almost certainly solve the problem. For exact recommendations designed to meet your special requirements, drop us a note outlining the problem, along with an actual sample of the surface. This service is offered without obligation of any kind.

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for guidance and control of aircraft and missiles.

"Controlonics" was coined by Daystrom from "computation" and "electronics" to express the functions of measurement, actuation, computation and control for industrial processes. It embraces both automation and instrumentation, fields in which the new group will be active.

Single-floor Flow for Precision-ball Plant

The Barden Corp., manufacturer of precision ball bearings, has started building a $2-million instrument-precision ball bearing plant in Danbury, Conn. Plans call for erecting a 125,000-sq ft manufacturing plant by next June. The plant will be devoted exclusively to design and production of instrument-precision ball bearings.

There will be a progressive, single-floor flow in the production process—starting with raw material storage and moving through assembly operations into packaging and shipping. Production will flow in U shape around a central service area that will contain the gage room and other departments servicing manufacturing activities.

Firm Aims at Iron-powder Market

Alan Wood Steel Co., Ivy Rock, Penna., will soon build a $36-million, 50-ton-per-day iron-powder plant. President Harleston R. Wood stated

(Continued on page 193)

"More coming? Where are we gonna put them?"

all from ONE dependable source

Reinforced Plastic Sheets, Channels & Angles

STRICK'S LAMICOR offers a basic material with a unique combination of chemical, electrical, thermal and mechanical properties. Lamicor offers a single material for use where heretofore multi-material construction was required to gain desired properties. Other Strick reinforced plastics are Glazor flat industrial glazing panels and Daycor corrugated sheets.

Plastic and Multi-Material Laminates

STRICK'S LAMICLAD comes in various grades such as polyester resin and fiber glass reinforced polyester resin press bonded to outdoor grade plywood. A number of other laminates are available from stock and sheets to your specific needs can be made on making orders.

Composite Structures—Honeycomb Panels—Chemical Foam Insulation

Strick's facilities are complete for the designing and building of composite structures in combinations of reinforced plastics, thermoplastics, chemical foam, metal and wood. Current production includes light weight all plastic refrigerator doors, honeycomb panels and partitions for heat barriers, protective screening and decorative walls.

Custom Vacuum Forming Service of Extra Large Forms

Strick's facilities for mold making and vacuum forming include the world's largest vacuum forming machine. Specialists in intricate patterns and deep draw of extra large forms.

Fabricated Parts of Plastic and Combination Parts

Strick's facilities include a complete machine shop for the fabrication of parts and complete assemblies in plastics or combinations of plastics and other materials including metal.

R & D Projects in Plastics

Inquiries concerning the use of any Strick products or services for your specific application will be promptly processed. Our engineering department is available for assistance in new product development and conversion projects.

Complete information, specification sheets and samples of any Strick Products or Services will be sent promptly on request.

STRICK PLASTICS
PERKASIE, PENNA.

Basic Material Producers of Plastics and Laminates
Custom Vacuum Forming—Specialists on Extra Large Forms
Product Engineering and Development in Plastics and Laminates
Composite Structures and Honeycomb Panels

HUGLOCK

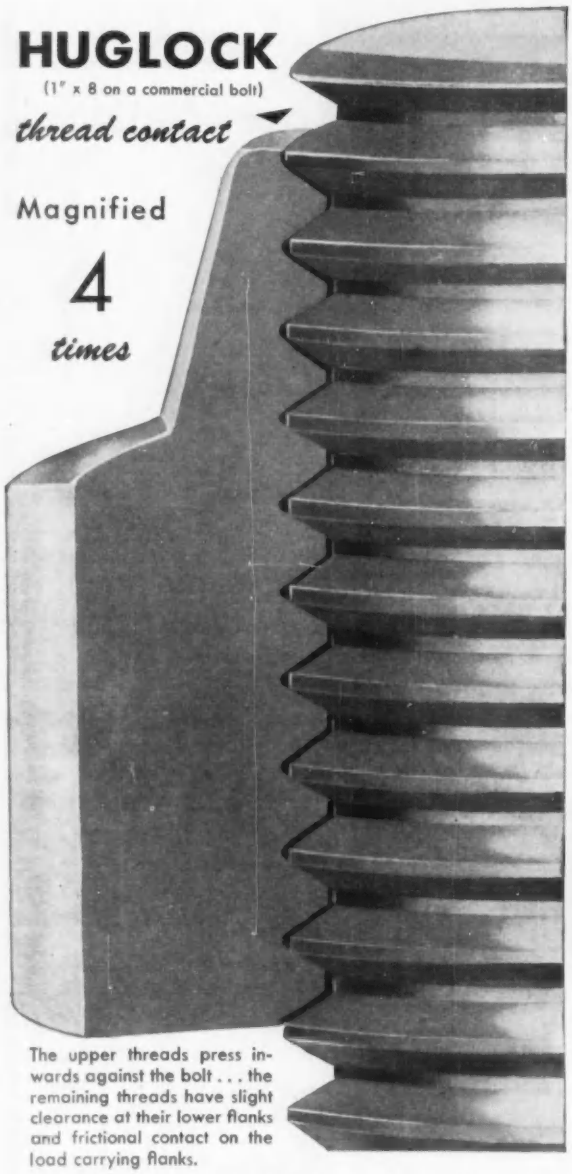
(1" x 8 on a commercial bolt)

thread contact

Magnified

4

times



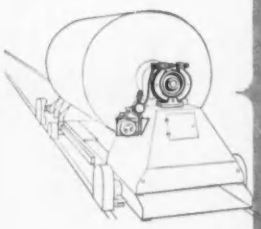
The upper threads press inwards against the bolt . . . the remaining threads have slight clearance at their lower flanks and frictional contact on the load carrying flanks.

"HUGLOCK" maintains its locking action through repeated removals . . . locks to the bolt, whether the nut is seated or unseated . . . eliminates axial thread play, which tends to make nuts creep from their seat and work loose, under severe vibration or shock . . . all lock washers, cotter pins, key plates, etc., may be eliminated . . . The "HUGLOCK" section of our new catalog, contains 24 pages, includes engineering data and prices and will be furnished upon request.

NATIONAL MACHINE PRODUCTS COMPANY

Manufacturer of Standard and Special 12 Point and Hexagon Nuts . . . "Huglock" and "Marsden" locknuts.

44225 Utica Rd., UTICA, Michigan



WAGNER MANUAL TENSION CONTROL SYSTEMS

These manually adjusted tension control systems are finding extensive application in paper converting roll mill stands. They keep tension on the roll as paper is fed out—provide for emergency stops.

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Plans for a multi-million dollar expansion of the manufacturing and engineering facilities of Weston Hydraulics, Ltd., have been disclosed. The company, a subsidiary of Borg-Warner Corp., will construct a 75,000 sq ft building in Van Nuys, Calif., for the development and production of hydraulic and pneumatic equipment for aircraft, missiles and rockets. The new plant will eventually employ approximately 1000 persons.

New Laboratory to Study Bearings and Bushings

A half-million dollar research laboratory will double the research facilities of the Johnson Bronze Co., of New Castle, Pa., producers of sleeve bearings and bushings. Construction of the two-story building is scheduled to begin this fall; occupancy is expected in a year.

All activities formerly performed by the Research Department and the Product Engineering Department now have been combined into one unit—Product Engineering and Development.

Engine Test Laboratory

A new test laboratory for research into and development of components for aircraft turbo-jet and industrial gas turbine engines will be constructed in Tonawanda, N. Y. by the Eaton Mfg. Co. The $750,000 laboratory, which is scheduled for completion this year, will contain 13,000 sq. ft. of floor space and will house complete engine testing facilities for hot and cold tests, air blowing machinery, dynamometers, torque measuring apparatus, and an instrument control room, as well as office and work shop areas. Initially, it will employ about 40 engineers.

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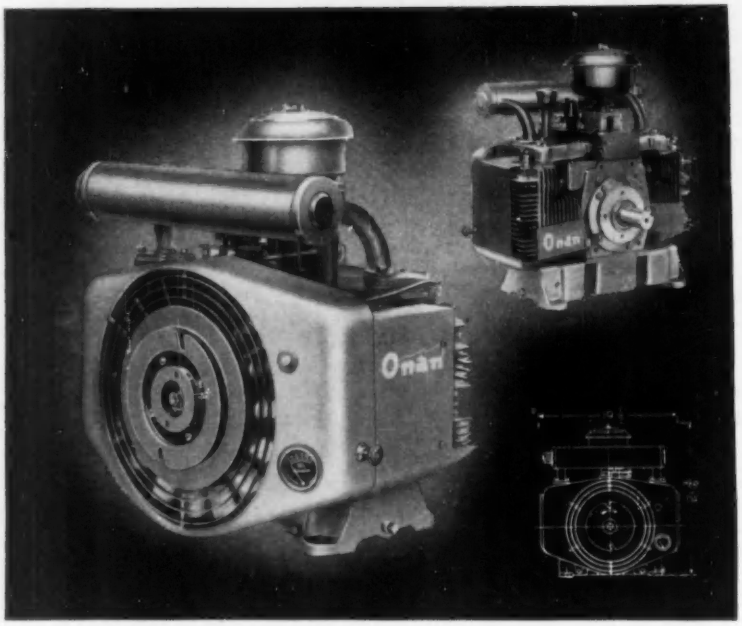

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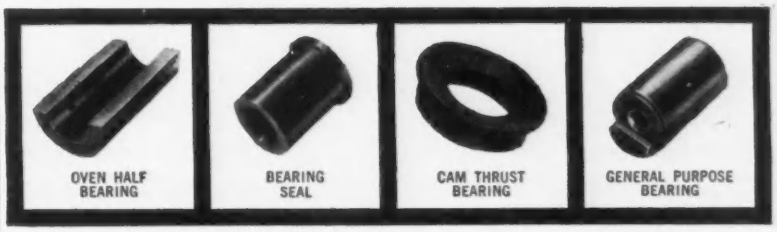

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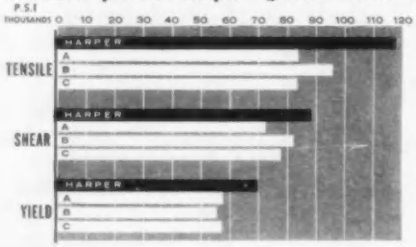

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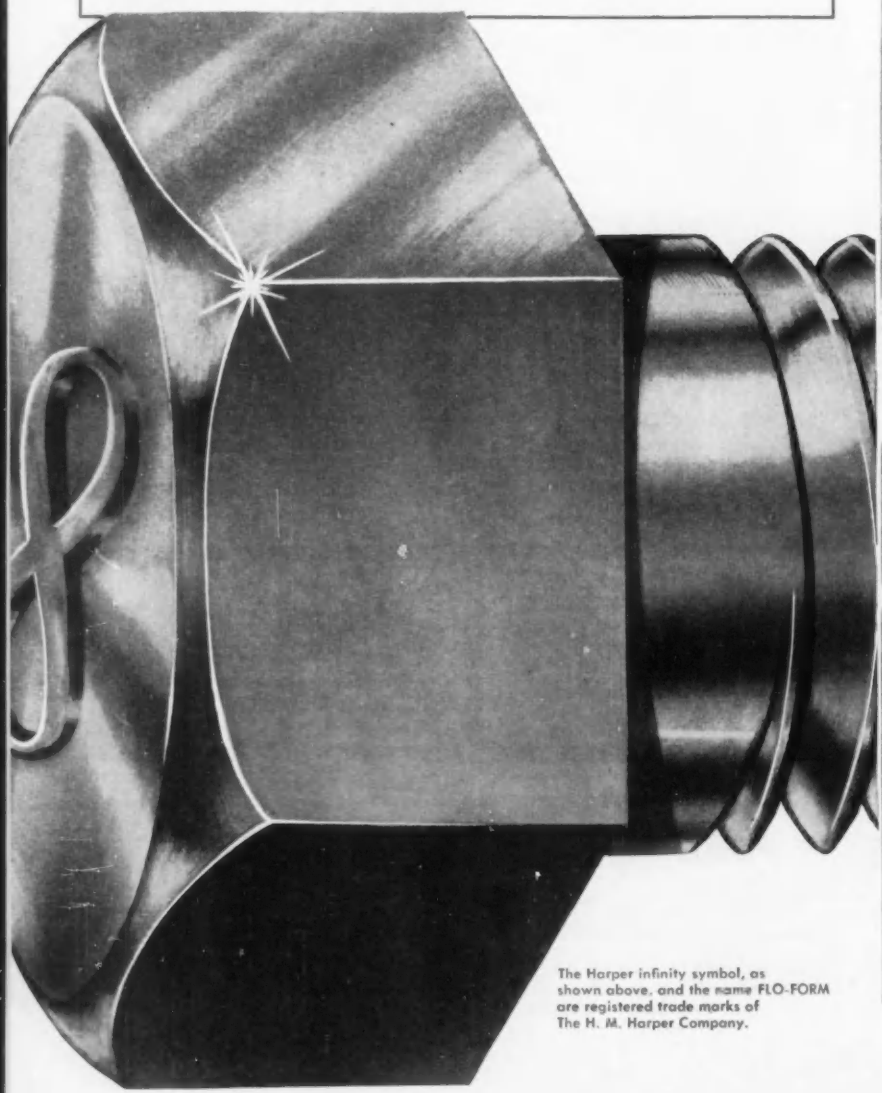

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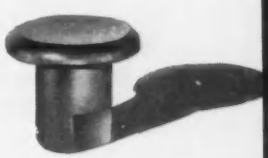

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Seam Welding—How to Use It To Improve Product Design and Quality

What is Seam Welding?

Seam welding is a method of fastening two metal piece parts with an uninterrupted joint, such as cylinder side seams, joining fuel tank halves, etc. It is a process that lends itself efficiently and economically to electric resistance welding techniques.

In practice, the two pieces of metal to be joined are overlapped and passed between a pair of rotating electrode wheels. Current is passed through in such a manner as to produce a line of overlapping spot welds. The resultant seam is pressure tight.

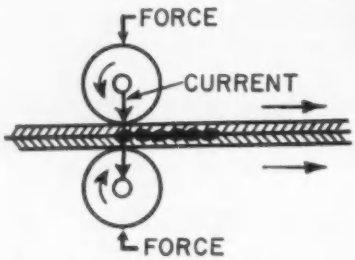

Fig. 1 Seam welding process.

Variations of the seam weld include *roll spot welding* in which the welds are made in the same manner but not overlapping. This method permits highly accurate spacing of spots.

Another form is the *mash seam weld* in which the materials to be welded are overlapped from one-half to twice the thickness of the sheet. The seam welder wheels actually mash or flatten the weld area to produce a seam only slightly thicker than one sheet of the welded material.

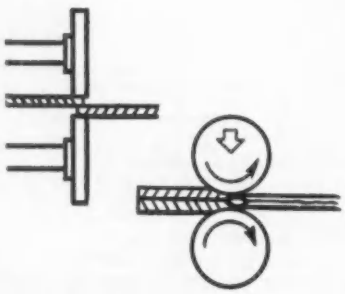

Fig. 2 Mash welding process.

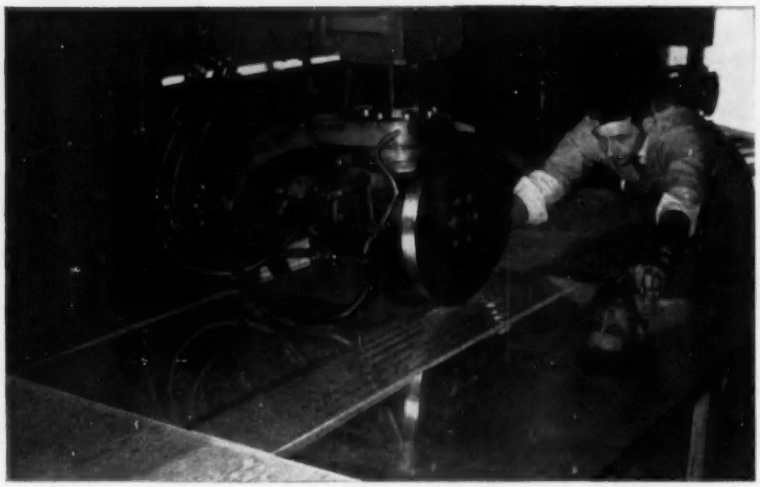

Fig. 3 Roll spot operation welding .125" to .125" of flat sheet aluminum alloy.

Advantages of Seam Welding

The seam welding process is readily adaptable to high production work which requires long linear welds. Pressure tightness is inherent.

Appearance of the weld is good. Minimum finishing is necessary only where surface appearance is critical. Distortion, so common in fusion welding, is negligible.

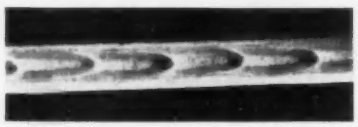

Fig. 4 Macrograph for continuous seam weld of .032" to .032" 24ST Alclad aluminum. Overlapping of the welds insures a water and fume tight seam.

Design Considerations for Seam Welding

As a guide to spacing which will produce an air or water-tight weld, there should be approximately 12 spots/in. in lighter gauges at a production rate of 12 feet/min. For heavier gauges figure about 8 spots/in. at a 2 feet/min. production rate.

Functional joint design will provide considerable savings if the piece part edge distance and work clearance can be accommodated by standard welder arms and electrode wheels.

Sciaky Research Assistance

Facilities of the Sciaky Research Division at Los Angeles, California, are available for contract research to answer resistance welding problems. Housed in a 15,000 sq. ft. building, these facilities include an experienced engineering staff, a complete range of the most advanced resistance welding machines including the largest in the world and a laboratory equipped for metallography, chemistry, electronics, photography and testing as applied to resistance welding. Write for further information and ask for the 20-page Research Division brochure.

Write Today for Free Sciaky Literature

Start to build your data file on resistance welding today. Designers' Guide Bulletin 331 discusses seam welding and other forms of resistance welding.

Describe your particular fastening problem on company letterhead and we will send suitable back and future issues of our "Resistance Welding At Work" publication. All contain impressive examples of Sciaky's basic thinking—resistance welding techniques designed to do *more useful work at lower operating costs* with *maximum reliability*. **Sciaky Bros., Inc., 4913 West 67th Street, Chicago 38, Ill., POrtsmouth 7-5600.**

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For your copy of any new catalog or bulletin, circle key numbers in the space indicated. Bulletins are described on pages 159-164.

To get more data about new Components, Materials and Parts fully described on pages 101-154, just circle the appropriate key number.

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7—Industrial Solenoid Valves
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9—Beryllium-copper Spring Pins
10—Two-way Solenoid Valve
11—Gage Protector
12—Light-duty Caster
13—Switch with Taper Pins
14—Footswitches
15—Power Supply for Dc
16—Spherical Bearings
17—Diaphragm Seals
18—Transistorized Power Supplies
19—Gray Rubber Wheel
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21—Hollow Shaft Gear Motors
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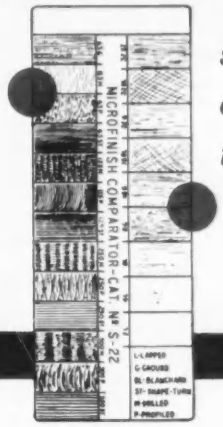

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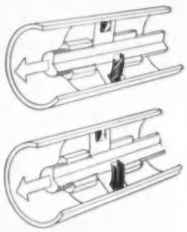

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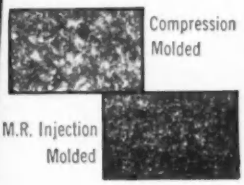

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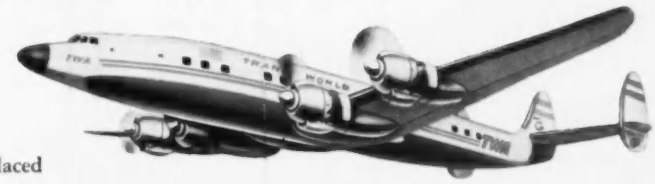

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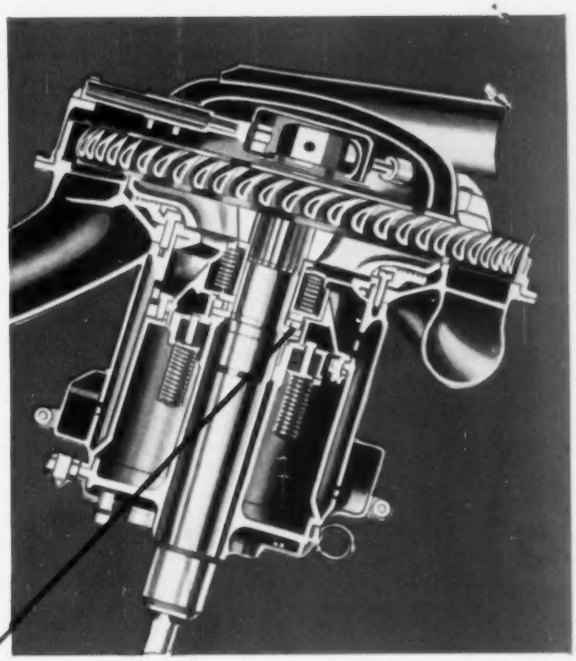

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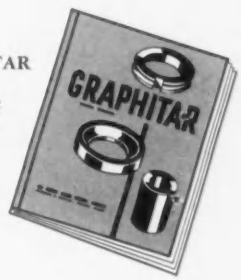

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